CANADIAN ELECTRONICS ENGINEERING

DECEMBER 1959
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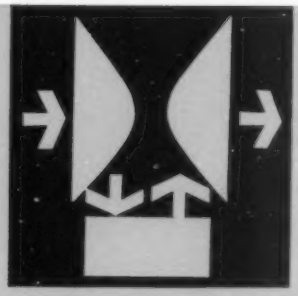
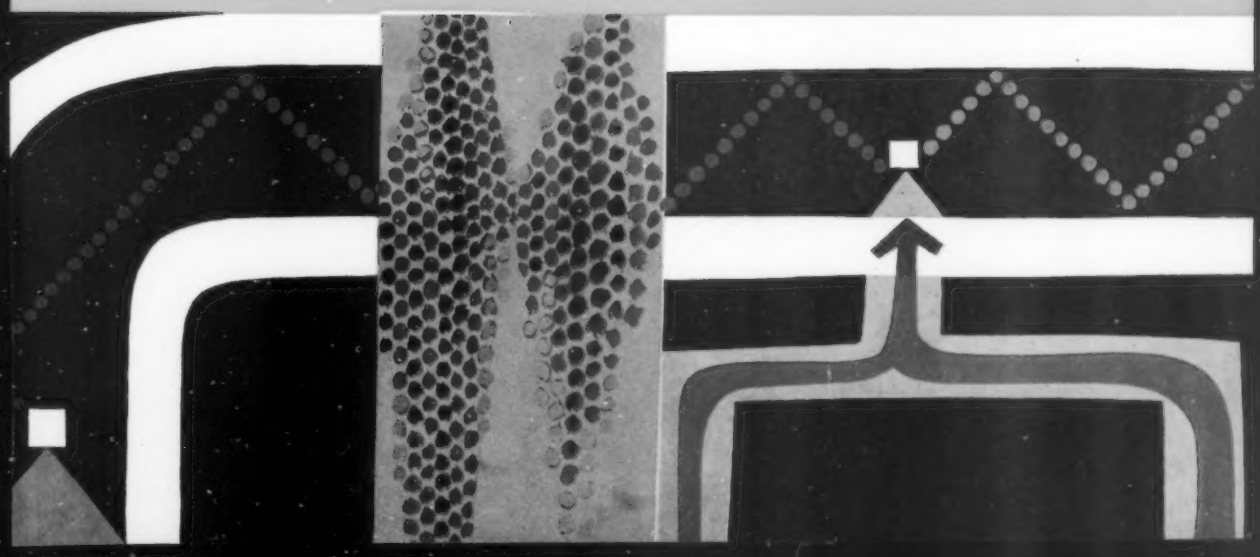


Microwave Communications in Canada



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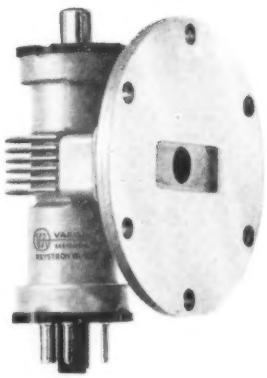

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December, 1959

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cover design

Cover artist G. N. Reilly has tried to capture the over-all idea of microwave communications without using the familiar landmarks of tower and reflector.

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CANADA PICTURES

MacDonald

DUTTON

Simpson

LANDRY

Cardella

authors and articles in this issue:

This issue of CEE has been prepared to review the status of microwave communications in Canada. The authors are well-qualified to discuss their respective fields.

K. J. MacDonald was born in Port Arthur, Ont. He graduated from the University of Toronto in 1947 and has been with Canadian National Telegraphs since then. He was appointed assistant general radio engineer in 1957.

J. C. D. Mallet-Paret received his early education in Kelowna, B.C. After discharge from the RCAF he entered University of British Columbia and received his degree in electrical engineering in 1951. He served three years with Northern Electric Co. Ltd., and has been radio systems engineer with Alberta Government Telephones since 1954.

O. Cardella graduated from McGill University in 1941, then joined Montreal Light, Heat & Power Consolidated (now the Quebec-Hydro Electric Commission). After a variety of assignments he was appointed control and communications design engineer in 1958.

J. R. Simpson started this microwave issue by suggesting that CEE editors take a good look at the state of the art in Canada. Mr. Simpson spent several years as a technical writer with Electronic Associates Ltd.; he is also editor of the Proceedings of the Canadian Astronautical Society. Since March 1959, he has been with the Carrier and Radio Div. of Automatic Electric Sales (Canada) Ltd.

John Christenson has been with United States Motors Corp. 18 years and risen up from draftsman, through engineer and chief engineer to his present position of vice-president, engineering. He holds a number of patents.

R. P. Matthews is a graduate of the University of Saskatchewan, (Maths & Physics, and Eng. Physics). After serving with Andrew Antenna Corp. Ltd. as director of sales and engineering, he was appointed to the position of manager of the company in 1958.

G. A. Collins has served with both the RCAF and the Canadian Army. In 1949 he graduated from the University of Toronto, electrical engineering, and formed his own company, Micro-Tower Ltd. in 1955.

Since he joined the Bell Telephone Co. of Canada in 1922, **S. Bonneville** has been associated with nearly all phases of transmission. In 1947 he was assigned to radio work. He is chairman of the radio committee of the Telephone Association of Canada.

Matthews

Mallet-Paret

Christenson

Bonneville

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NEWS HIGHLIGHTS

RCA Victor Co. Ltd. has been awarded a $20,000,000 contract by CNR to build a 1,200-mile microwave system from Grande Prairie, Alberta, to Snag, Yukon.

On September 8, Canadian National Railways awarded a contract to RCA Victor Co. Ltd., Montreal, for construction of a microwave link in Western Canada. It will form part of the communications system between Norad headquarters in Colorado Springs and the radar stations across the northern part of Canada. For reasons that have not been divulged, news of the RCA contract was kept secret until the middle of November. This delay gave rise to many conflicting rumours, some of which may have damaged Canada's position with respect to integrated defence production. For more news about the project see page 9.

National Research Council and University of Toronto are going to build a radio telescope in Algonquin Park, Ontario

This new radio telescope, to be part of a National Radio Observatory at Lake Traverse in Algonquin Park, will use a T-shaped antenna measuring 400 feet in each arm. Estimated cost is about $20,000.

U. S. military orders placed in Canada during past 12 months have increased 50% over previous year. Sub-contracts were responsible for most of increase.

During the past twelve months Canadian firms have received $70,000,000 worth of American military orders. This represents a gain of almost 50% over the previous twelve months, but is still a long way from the estimated 200-300 million dollar market that U. S. observers feel could be obtained by Canadians. Our companies will have to learn new technologies as North American defence swings away from manned aircraft and concentrates on guided missiles.

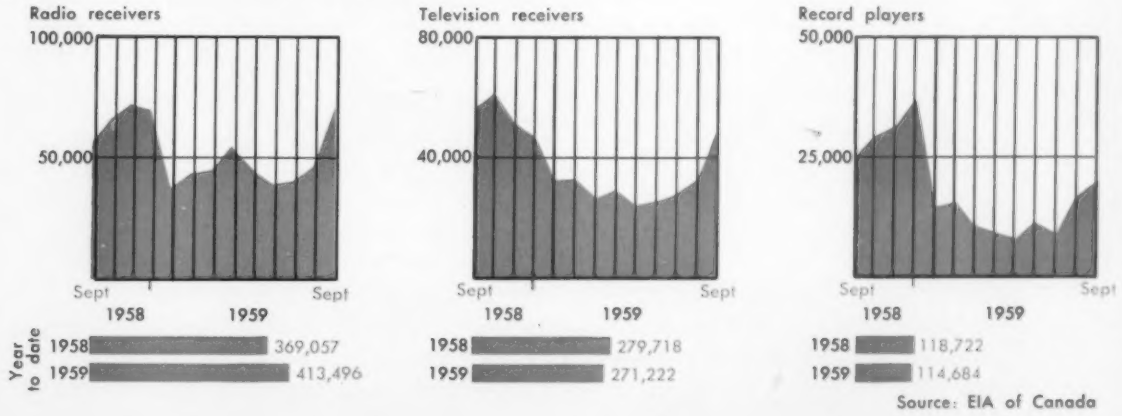
75% of Canada's households now have tv receivers, an increase of 5% over 1958. 96% have radios, 81% have telephones.

Dominion Bureau of Statistics' annual survey shows that electrical appliances were still on the increase. Topping the list in the rate of increase over 1958 were tv receivers with sets now in use close to 75% of the estimated 4,303,000 households versus 70% in 1958. Some 96% had radios in both years and nearly 81% had telephones this year, versus 79% in 1958.

A new microwave system has been started to connect Rimouski, Quebec, with New Carlisle, N.B. The 142-mile link will carry French-language tv programs.

Canadian Pacific-Canadian National Communications engineers have started construction work on a new microwave system which will provide a French-language tv signal to New Carlisle, N.B. Repeater stations will be built at St. Gabriel, St. Vienney, Ste. Florence and St. Alexis in the Gaspe Penninsula; at Dalhousie, N.B. and back across Baie des Chaleurs to Mt. Carleton where a spur repeater station has been built to provide a tv signal for New Carlisle. A second section will be built from Dalhousie to Moncton, N.B. later.

Radio sales continue to climb: now 12% ahead of 1958



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IT&T Electronics Service elects Hoodspith general manager

Hoodspith

The board of directors of IT&T Electronics Service Co. of Canada Ltd. have announced that **R. R. B. Hoodspith** has been elected general manager and member of the board. Prior to this, Mr. Hoodspith was a Wing Commander in the RCAF in charge of No. 1 Radar and Communications School at Clinton, Ont. He replaces J. T. Robertson, who is accepting a new position within the company's parent organization.

Mr. Hoodspith was born in Carnduff, Sask., attended schools in Vancouver, and began his career as a marine radio operator. He has been with the RCAF since 1937, serving as a pilot and electronics officer. After World War II he was named Deputy Director of Radar in the Directorate of Signals Air Force Headquarters. In 1951 he was assigned to Supreme Headquarters Allied Powers in Europe (SHAPE) as Chief of the Radar Section and served throughout the NATO countries as head of the SHAPE Air Defense Evaluation Team.

Canadian Admiral branch manager

New manager of the Ottawa sales branch office of Canadian Admiral Corp. Ltd. is **Alex McQueen.** He has been a member of the Toronto branch sales staff since joining the company.

Canadian has triple appointment

Vice-president of Robertshaw-Fulton Controls (Canada) Ltd., **G. A. Elliott,** has been elected to the board of directors of the Canadian company. In addition, Mr. Elliott has been appointed a vice-president of Robertshaw-Fulton Controls International Co., and elected a director of that company.

Mr. Elliott was born and educated in England, but has resided in Toronto for a number of years.

Elliott

VINCENT

Hastings

Sales engineering appointment

R-O-R Associates Ltd. have appointed **W. W. Hastings** to their sales engineering staff to serve the Western Ontario district. Mr. Hastings is a graduate of the University of Toronto, electrical engineering. He has done research work with the British Iron & Steel Research Association, and has been associated with both Westinghouse Corporation and Canadian Westinghouse Co. Ltd.

Expansion at Astral brings promotions

Astral Electric Co. Ltd., Toronto has promoted a number of staff members and added to their staff to take care of increased sales activity. Sales promotion becomes the responsibility of **D. W. Rippin,** former export sales manager of Belling & Lee, Ltd. W. Stephens now becomes sales manager of Astral Music Sales.

B. Coyne, former Astral sales representative in Montreal, has been transferred to Toronto to join the Ontario sales force. Replacing him in Montreal is **G. Smith,** formerly with Sperry Gyroscope Co. of Canada Ltd.

J. Bastow has been appointed western sales representative, based in Vancouver. He has been in charge of hi-fi component sales with J. J. H. McLean & Co., Winnipeg.

1,000 engineering technicians certified in Ontario

The 1,000th person to be certified under Ontario's engineering technician and technologist certification program, **Cary B. Alexander** of Islington, received his certificate last month from Ontario's Labor Minister Charles Daley. Mr. Alexander graduated from the Ryerson Institute of Technology in 1955, but has continued taking night-school courses.

Broadcast sales representatives

Canadian General Electric Co. Ltd. has appointed two engineers as broadcast sales representatives. **Peter G. Bowers** will cover eastern and northern Ontario, and **Harry K. Davis** will cover south-western Ontario and Manitoba.

MILNE

Davis

ANDERSON & COLE

Bowers

Mr. Bowers, from Brampton, Ontario, joined CGE after graduation from the University of Toronto, Engineering Physics, in 1956. Mr. Davis, from Belleville, Ontario, graduated from Queen's University in 1955. He specialized in communications and joined CGE upon graduation.

Ottawa bureau

Don Peacock, Parliamentary Press Gallery correspondent for Canadian Press since 1954, has been appointed Ottawa editor for Canadian Electronics Engineering. This will enable CEE to report the happenings in the nation's capital in even greater depth and detail than in the past. Mr. Peacock will retain his Parliamentary Press Gallery membership.

Mr. Peacock was born in High River, Alta., received his public and high school education at Lethbridge, then continued his studies at Bob Johns University, Greenville, S.C., and Roosevelt College, Chicago. He has been with Canadian Press since 1949.

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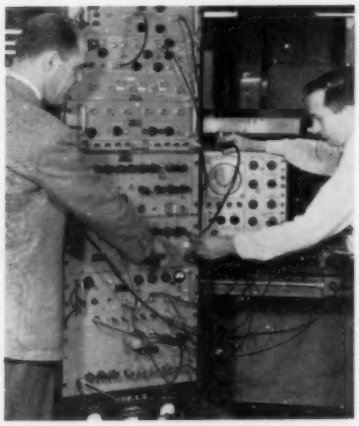
RCA Victor gets contract for Alaska microwave link

Canadian National Railways has awarded a contract to RCA Victor Co. Ltd., Montreal, for erection of a 1,200 - mile microwave communications system from Grande Prarie, Alberta, to the Yukon-Alaska border. This project, which involves an ultimate expenditure of close to $25,000,000, will form part of a microwave network linking the State of Alaska with the rest of continental United States.

The engineering and construction work, virtually all of which will be done by Canadians, is now well under way. It is expected to provide over 1,000,000 manhours of labor before the contract is completed in about two years' time.



RCA Victor engineers Pullan (1) and Kydd with rack of microwave equipment for new 1,200-mile Alaska link.

The system will comprise about fifty stations on a route generally following the Alaska highway. When completed it will have channels sufficient to accommodate 600 telephone and telegraph channels. In the future, additional equipment could be added to provide a channel for television transmission.

RCA Victor Co. Ltd. has now completed a number of microwave links in various parts of the world. It is the central microwave organization for the international division of Radio Corp. of America, providing most of the engineering and production facilities for this type of equipment.

New wire and cable plant

Standard Wire and Cable Ltd. have announced plans for a new $1-million plant to be built on the western outskirts of Toronto. It will have 130,000 sq. ft. and is scheduled to be completed by April 15, 1960.

Data transmission seminar

Automatic Electric Sales (Canada) Ltd. sponsored a seminar in Montreal in mid-November to acquaint engineers with recent trends in data transmission. Delegates attending the two-day meeting included engineers from companies manufacturing data processing equipment, communications companies, and companies interested in transmitting data from point to point. The seminar will be repeated in Edmonton next April.

Tung-Sol forms Canadian Division

The Canadian Division of Tung-Sol Sales Corp., a subsidiary of Tung-Sol Electric Inc., has been formed to distribute automotive products throughout Canada. **E. Leslie Peter** has been named sales manager of the new division with headquarters at 1117 St. Catherine St. West, Montreal 2.

Peter

Beck

Hellermann opens company in U. S. A.

Hellermann Corp., with factory and warehouse space in Buffalo, N.Y., will now manufacture many of the products formerly made in Canada for the American market. Sales will be under the direction of **C. Beck,** who has been with the Canadian company.

Industrial show rooms

Alpha Aracon Radio Co. Ltd. officially opened its new head office and showrooms at 555 Wilson Ave., Toronto. They have established one showroom that will be used for industrial electronics meetings from time to time.

(Continued on page 68)

Ottawa report

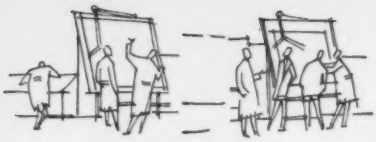
This is the first of a new feature in CEE. Significant news items from Ottawa will be presented here by our newly-appointed Ottawa editor, Don Peacock. (See page 7).

The nation's capital has become the first city in Canada to synchronize its downtown traffic lights. The lights can be adjusted automatically from a master control panel in Ottawa traffic engineer Nielson's office to accommodate inbound morning traffic and outbound motorists in late afternoon. It encompasses 80 of the city's 125 traffic-lighted intersections and is credited with speeding rush-hour traffic by opening a steady string of green lights for drivers instead of alternating haphazardly at every intersection with a red light then a green and so on. So far the system has cost $75,000 and another $25,000 is expected to be spent on expanding it next year. The system, designed and built by the Littlefield-Alger Signal Company in New York with component parts from Canadian General Electric, connects each signal light to the master control panel with telephone lines.

Will Canada be working out a defense production-sharing arrangement with France next?

The question was raised by a Canadian Press report quoting an unidentifed defense department spokesman as disclosing that Canadian soldiers are being trained on the French SS-10 anti-tank missile at the Royal Canadian Armored Corps school at Camp Borden, Ontario. The question of production sharing could not be answered at once — the report said no decision had yet been made to adopt the missile.

What is the current image of Canada in the eyes of businessmen abroad? Here's an answer — undoubtedly subjective — given by Lionel Chevrier, Liberal MP for Montreal Laurier constituency and former transport minister, in a speech on his return from a trip to Europe: "In England, the feeling is one of disappointment at the meagre results of the proclaimed intention to tighten Commonwealth ties. In France, some corporations with capital available for investment in Canada are holding back because of our monetary policies. In Germany, Canada is considered a U. S. satellite."



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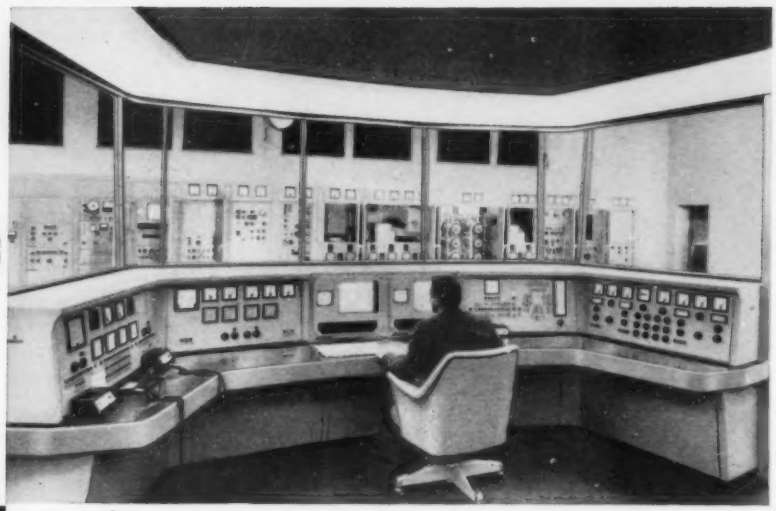

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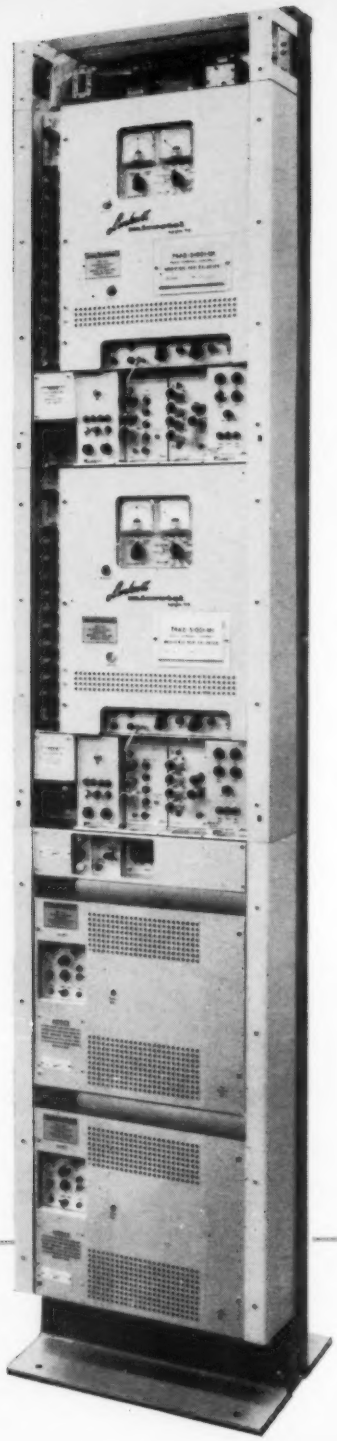

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Only the WESTON VAMISTOR®

offers performance like this!

Here, at last, is a precision metal film resistor which offers substantial advantages over all other types—wire wound, deposited film, etc. Look at this list of VAMISTOR capabilities and characteristics:

- VAMISTOR HANDLES HIGHER WATTAGES. Up to 8 full watts at 40 C for Model 9849-2.
- VAMISTOR OFFERS HIGHEST RESISTANCE RANGES. For example, 1.5 megohms in ¼-watt size . . . 5 megohms, ½-watt.
- VAMISTOR HAS OUSTANDING THERMAL CHARACTERISTICS. Runs cooler . . . resists thermal shock. Standard temperature coefficient doesn't exceed 50 ppm/°C.—lower than Nichrome wire. Also available with maximum of 25 ppm/°C. Temperature coefficients don't vary over the resistance range.
- VAMISTOR OFFERS UNUSUALLY LONG SHELF LIFE, STABILITY. Exclusive process of fusing element to inside of steatite tube assures long life, improved resistance to all environmental conditions.
- VAMISTOR IS MORE RELIABLE; HAS GREATER MEAN-TIME-TO-FAILURE.
- VAMISTOR PRODUCES NO CORONA; IS AS NOISE-FREE AS BEST WIRE-WOUND RESISTORS.
- VAMISTOR OFFERS EXCEPTIONAL PERFORMANCE UNDER RADIATION.
- VAMISTOR ACCOMMODATES HIGHER MAXIMUM CONTINUOUS WORKING VOLTAGES.
- VAMISTOR IS VIRTUALLY NON-INDUCTIVE. Capacitance characteristics are superior to all other existing resistors.
- VAMISTOR IS SUBJECTED TO STRICTER QUALITY CONTROL THAN ANY OTHER RESISTORS.
- THE VAMISTOR LINE CONFORMS TO MIL-R 10509C CHAR. C. Styles RN-65, RN-70, RN-75 and RN-80.

MIL STYLE	WESTON MODEL	WESTON DIMENSIONS	
		LENGTH	DIAMETER
RN-65, RI-92	9855-2	0.650	0.235
RN-70, RI-94	9852	0.866	0.312
RN-75, RI-96	9850-2	1.120	0.411
RN-80	9849-2	2.156	0.411

For full information, call or write: Daystrom Limited, 840 Caledonia Road, Toronto 19, Ontario, or 5430 Ferrier Street, Montreal, Que., a subsidiary of Daystrom Incorporated, or any office of Northern Electric Co. Ltd.

WESTON

Instruments

A DAYSTROM UNIT

WORLD LEADER IN MEASUREMENT AND CONTROL

For further information mark No. 33 on Readers' Service Card

the new generation of MAGNET

Is there a better type of magnet wire for your job today? "Yes", has been the answer to many Canadian companies.

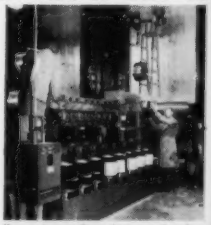
Production is completely automatic at the Canada Wire Magnet Wire plant at Simcoe.

Several factors, including miniaturization of equipment and the introduction of higher speed winding machines have resulted in a new generation of magnet wires.

Perhaps one of the new types (a few are described below) will suit your requirements much better than the one you are now using.

There is one sure way to find out. Tell us about your product and manufacturing process. Canada Wire makes all the latest types of magnet wire, so Canada Wire is best equipped to advise if there is now a better type of magnet wire for you.

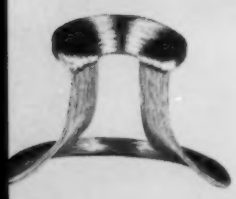
One reason why Canada Wire is able to offer such specialized magnet wire service to industry is the modern research and manufacturing facilities centralized in the Magnet Wire Division plant at Simcoe, Ontario... the first Canadian plant devoted solely to the specialized job of producing the new generation of magnet wires for you.



Every type of modern packaging is offered; Pail-Paks, Barrel-Paks and a complete range of spool sizes.

BONDEL

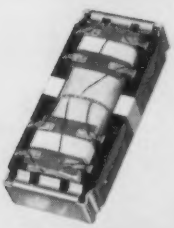
A Formel insulated wire with a thermoplastic cement overcoat. This overcoat softens when exposed to heat (275°F) or solvents (alcohol). Will bond the wires in a desired shape on cooling.



Deflection Yoke Coil for Television

NYLON

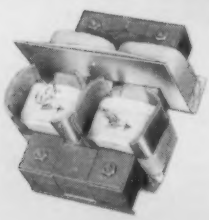
A polamide coating wire characterized by excellent windability and ability to solder in dip operations at temperatures of 650°F. to 750°F. without prior removal of coating.



Fluorescent Lamp Ballast Transformer Coil

PLAIN ENAMEL C-90

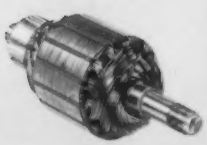
Insulated with an oil resin varnish film. Provides outstanding electrical properties in very thin film build-ups.



Oil Burner Ignition Coil

POLYSOL-N

Polysol insulated with a nylon overcoat. Combines the excellent windability and solvent resistance of nylon with the outstanding electrical characteristics of polysol. For soldering in dip operations without prior removal of coating.



Automotive Generator Armature

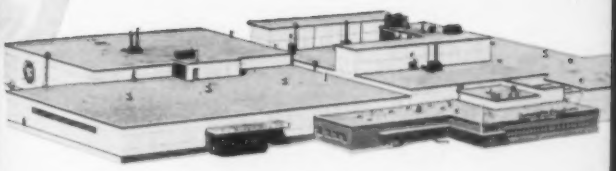
WIRES

POLYSOL

A modified isocyanate coated wire characterized by its excellent electrical properties (particularly at high frequencies) and its ability to solder in dip operations without prior removal of the insulation.

FORMEL

The best general purpose magnet wire now being manufactured. It is a vinyl acetal coated wire that has many outstanding properties for use in equipment functioning at temperatures not exceeding 105°C.



Canada Wire's 113,000 square foot Magnet Wire Division plant was engineered from the ground up to manufacture one thing—magnet wire. Here, are the specialists and specialized equipment it takes to produce the new generation of magnet wires to the highest quality standards.

Electronic IF Transformer Coil

Fan Motor Stator Winding

TRADE MARK REG'D.

Canada Wire and Cable Company Limited

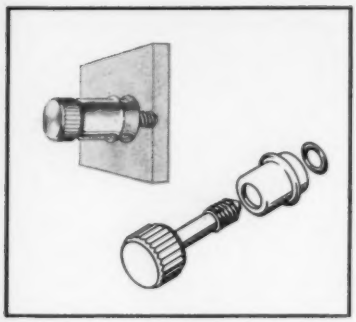
Magnet Wire Division—Simcoe, Ontario

A *Canadian* Company Manufacturing and Selling Coast to Coast

Compact Captive Panel Screws:

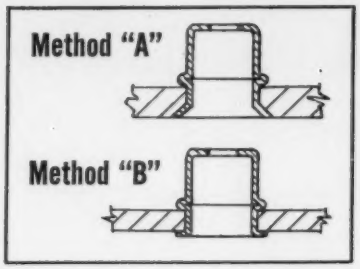
Standard Design Lowers Installed Costs

No longer is it necessary to resort to a costly fastening device of special design to provide quick attachment and release of electronic components. Standard Southco Retractable Screw Fasteners (stand-off thumb screws), available from stock, are both fast to install and economical. The five sizes,

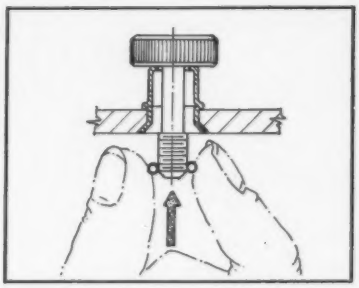


shown below, meet a very wide variety of requirements.

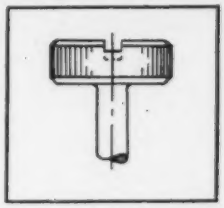
Check these advantages of simplified Southco Captive Panel Screws. Even when many screws are in one panel, misalignment is easily handled because the screw floats in a large hole in the stand-off, allowing ample play for "lining up." No special tools are



needed for installation, thus production is not subject to tool failure, nor limited by either the number of special tools available or the number of personnel trained in their use.



The Southco No. 58 Retractable Screw Fastener consists of three parts: thumb screw, stand-off, and retaining ring. The bright nickel-plated brass stand-off is inserted in either a drilled and countersunk hole (Method A), or a drilled hole (Method B), and flared. The polished, chrome-finished brass screw is passed through the hole in the stand-off and made captive by a retaining ring. Engaging in a tapped hole in the frame, the screw may be fully withdrawn without moving the panel, yet always is retained.



The unslotted screw is standard in 3/4", 9/16", and 7/16" head diameters and three thread sizes. Slotted head screws are also available in all sizes. The stand-off is standard in sizes to fit panel thicknesses from a minimum of 1/16" to a maximum of 17/64". Screw and stand-off are also obtainable in stainless steel.

MINIATURE TO LARGE SIZE HEADS IN FIVE TYPES

HEAD DIAMETER	3/4"	9/16"	9/16"	7/16"	7/16"
THREAD SIZE	1/4-20	1/4-20	12-24	10-24	10-32

Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed.

Represented in Canada by . . .

METAL AND WOOD FASTENING DEVICES
6302 Papineau Avenue
Montreal 35, Quebec

BLACK BROTHERS, LTD.
1200 Hornby Street
Vancouver, B.C.

WESTAIRE SALES CO.
380 Donald Street
Winnipeg 1, Manitoba

SOUTHCO FASTENERS
LION

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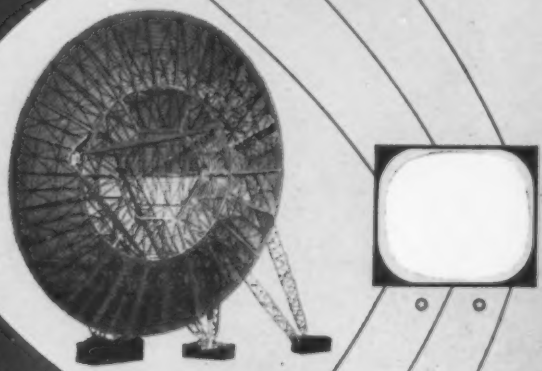
SERVING YOU BEST...

in communications



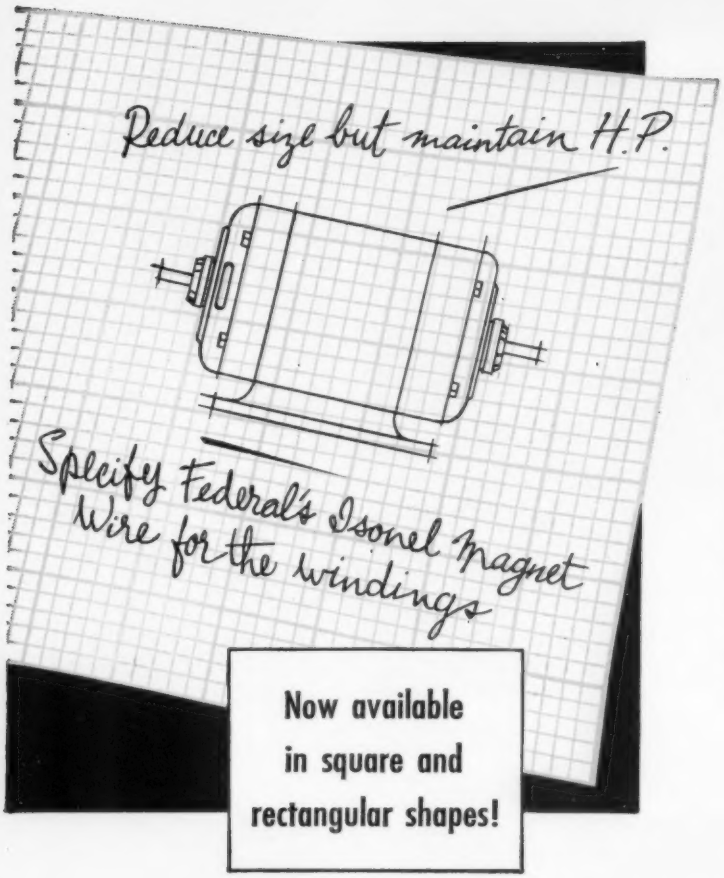
In the North a line of steel guardsmen stand on sentry duty with eyes sweeping the horizon, ears listening to the silence of the snowscape, by his television set a farmer is studying the weather report ... at your office the switchboard is receiving the first calls of the day. This is **communications**, where Northern Electric's research and development are pioneering new techniques and improving established ones.

The equipment for Canada's Trans-Continental Microwave system was manufactured and installed by the Northern Electric Company Limited, for the Trans-Canada Telephone System.

Northern Electric
Company Limited

SERVES YOU BEST

FEDERAL ISONEL
Solves High Temperature Motor Problems


Reduce size but maintain H.P.
Specify Federal's Isonel Magnet Wire for the windings
Now available in square and rectangular shapes!

The outstanding thermal properties of Federal's (Polyester) Isonel Magnet wire permit the operation of motors at higher temperatures—suitable for use at Class F (155°C) temperatures. This means the motor size can be reduced for a given horsepower, or greater horsepower can be obtained from a given size.

While having this advantage of higher operating temperatures, Federal's Isonel possesses the excellent heat shock, chemical and abrasion resistant properties of vinyl-acetal magnet wire. It has improved resistance to flow at high temperatures; and it does not craze, giving higher voltage breakdown and better shelf-life.

Available in Pay-Off Paks
13-23 in 250 and 500 lb.
24-29 in 100 lb. packs.

5901

Specify Federal . . . for the best in Magnet Wire.

FEDERAL WIRE PORTER **& CABLE DIVISION**

H.K. PORTER COMPANY (CANADA) LTD.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; PEERLESS ELECTRIC DIVISION; Specialty Alloys. RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A., and in Canada, Refractories, "Disston" Tools, "Federal" Wire and Cable, "Nepcoduct" systems. H. K. PORTER COMPANY (CANADA) LTD.

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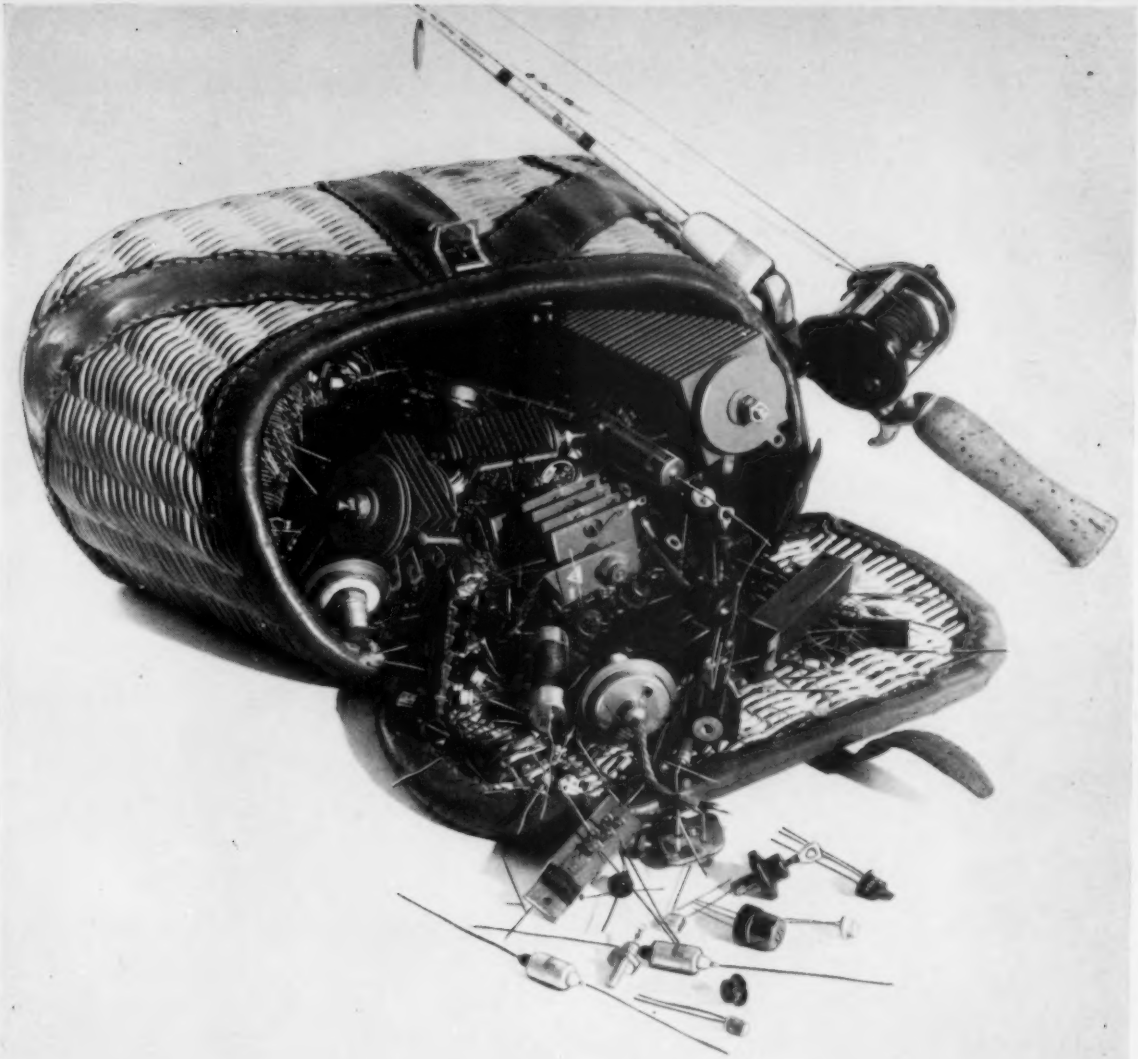

WHY 'FISH AROUND' FOR SEMICONDUCTORS?

Canadian General Electric can provide you with semiconductors needed for any application. In addition to the wide range produced in Canada, C.G.E. also supplies other makes and types under exclusive sales agreements. You save time, import problems and cut purchasing costs when you order semiconductors from C.G.E.

In addition, C.G.E. offers other important advantages including experienced sales engineers to help you select the right product, and application engineering to help you solve field problems.

So, why 'fish around' for semiconductors when C.G.E. can supply all your needs. For full information contact C.G.E., 189 Dufferin Street, Toronto

GENERAL ELECTRIC
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Electronic Tube Section

CANADIAN GENERAL ELECTRIC COMPANY LIMITED

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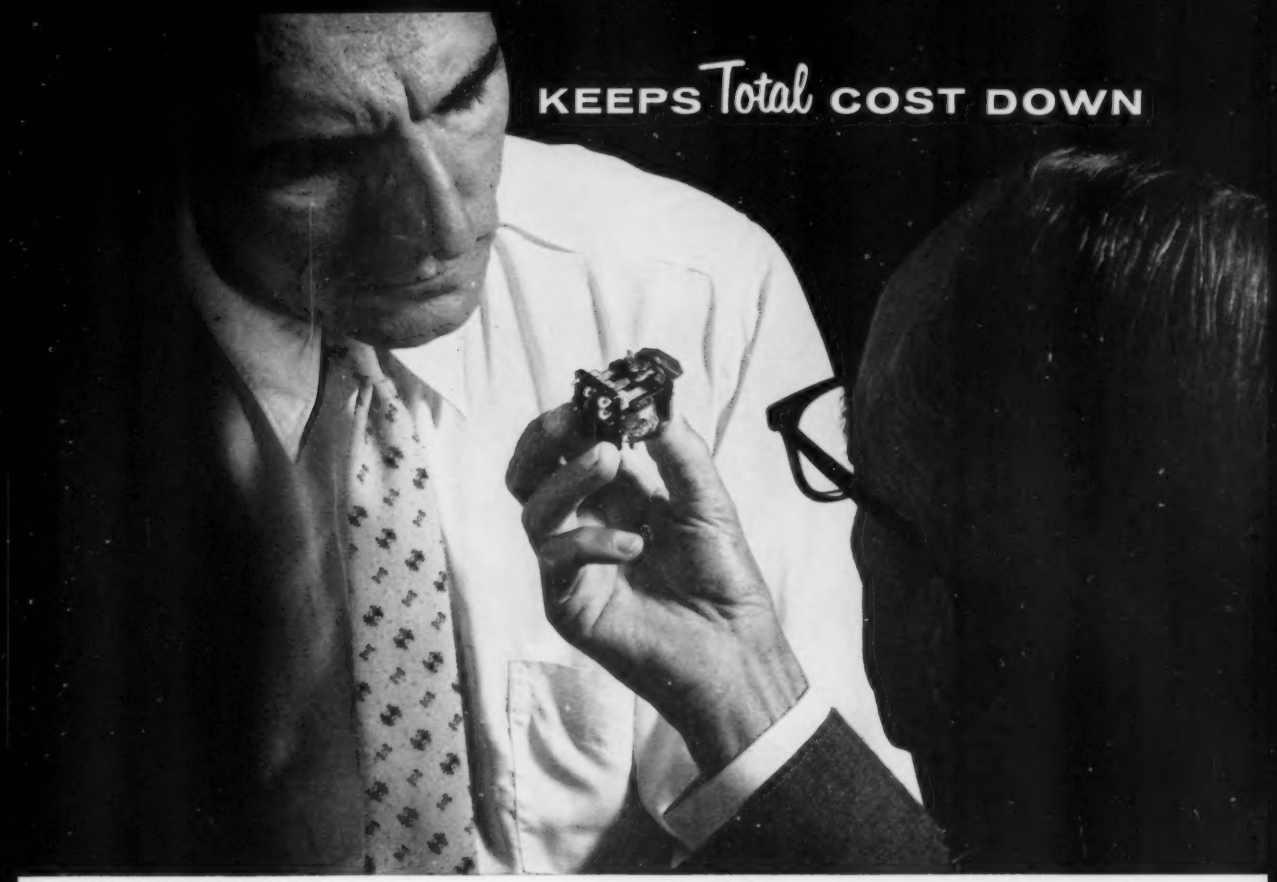


IF INSTALLED-COST IS A DESIGN PROBLEM

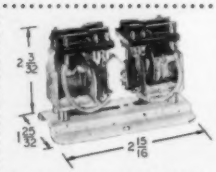
Look at the KA general purpose RELAY

What do your relays cost *installed?* Initial cost is never the whole story.

Our KA Relays are engineered for modern production methods. They're available with printed circuit, taper tab, quick-disconnect or hook solder terminals . . . are simple, economical to install. This fact, combined with low original cost, keeps your total cost down.

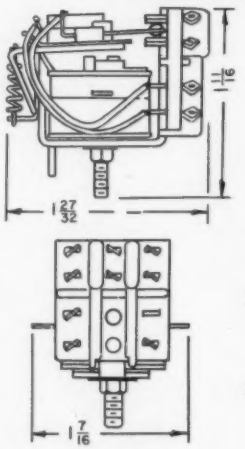
Another source for savings! All standard KA ac relays bear U/L and Canadian Standard Association seals of approval.

Write or call for more information or see the complete P&B catalog in Sweet's Product Design File.



KB LATCHING RELAY consists of two KA Relays, forming a mechanical latching relay, featuring a large number of contact arrangements.

KA ENGINEERING DATA



GENERAL:

Insulation Resistance: 100 megohms min.
Breakdown Voltage: 1500 V. rms between all elements.
Temperature Range:
−55° C. to +85° C. DC
−55° C. to +70° C. AC
Weight: 2.0 ozs.
Pull-In: DC 75% of nominal voltage.
AC 78% of nominal voltage.
Terminals: Taper tabs.
Printed circuit.
Quick-disconnect.
Pierced solder lugs.
Enclosures: Dust Cover
(max. 55° C. ambient for AC relays)
(max. 70° C. ambient for DC relays)

CONTACTS:

Arrangements: 3 Form C (3PDT) max.
Material: Movable—⅛" silver; stationary—$\frac{5}{32}$" wide silver overlay.
Load: 5 amps @ 115 V. AC 60 cps res.

COILS:

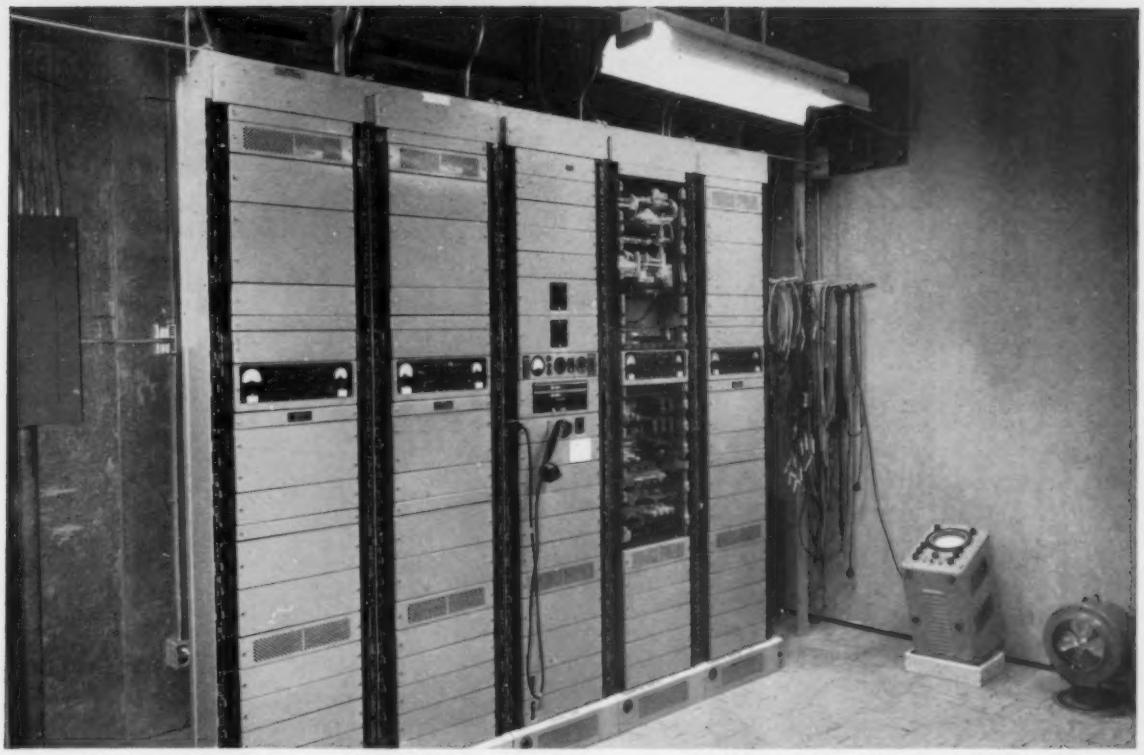
Resistance: 16,500 ohms max.
Power: 1.2 watts (DC), 2 volt amps (AC)
Duty: Continuous AC or DC (DC coils will stand 4.5 watts at 25° C.)

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD CANADA LTD.

GUELPH, ONTARIO

For further information mark No. 50 on Readers' Service Card



Scotch Mountain repeater station illustrating the compact arrangement for one regular and one protection radio path for message or TV transmission.

New Brunswick Link completed on schedule

LONG HAUL, 300 CHANNEL VOICE (OR COLOUR TV) MICROWAVE

Moncton to Saint John: the first link of the new East Coast microwave complex has already been completed as scheduled, and will go into operation December 12, 1959.

This microwave complex is a joint undertaking by The New Brunswick Telephone and Maritime Telegraph and Telephone Companies. Manufactured by General Electric Company of England, the microwave, multiplex and fault alarm equipment was engineered, furnished and installed by Canadian General Electric. Although this equipment had to be integrated with many items of existing plant, the ease with which the installation schedule has been met has already justified the confidence of the two companies.

Economy and dependability were major factors in this purchase. Both first and operating costs are minimized with G.E.C. equipment. Compact racks and unitized construction reduce space requirements. Full built-in metering and plug-in panels speed installation and reduce maintenance effort.

This G.E.C. microwave system is the culmination of many years of experience in the manufacture of all classes of telephone equipment. The decision to buy it for the Maritimes system was made after careful study of similar systems in operation in many parts of the world, and in the knowledge that complete servicing requirements can be furnished by Canadian General Electric.

Work is now proceeding on the sections from Saint John to Halifax and Sydney, and Moncton to Campbellton.

ELECTRONIC EQUIPMENT AND TUBE DEPARTMENT, 830 LANSDOWNE AVENUE, TORONTO C-159

CANADIAN GENERAL ELECTRIC COMPANY LIMITED

For further information mark No. 25 on Readers' Service Card

The new concept of electronic equipment manufacture

*** A new philosophy:**

Made for everyday use

Wide range available

Modern techniques

Flow production

Automatic inspection

Easy servicing

*Philips manufacturing plants have been completely retooled so as to produce a new, wide range of relatively inexpensive electronic measuring equipment.
Each instrument is in fact an electronic tool for everyday use in factory or laboratory: accurate, robust and reliable.
Philips have recently applied a new philosophy to the production of this type of equipment.
Users now benefit from the marriage of a highly specialised knowledge of these instruments and their applications with an unequalled experience in flow-line production. Here in fact is another substantial contribution by Philips to industry and to research.

Dependable **PHILIPS** *tools for the electronic industry*

Sold and serviced by Philips Organizations all over the world

Further information will gladly be supplied by:

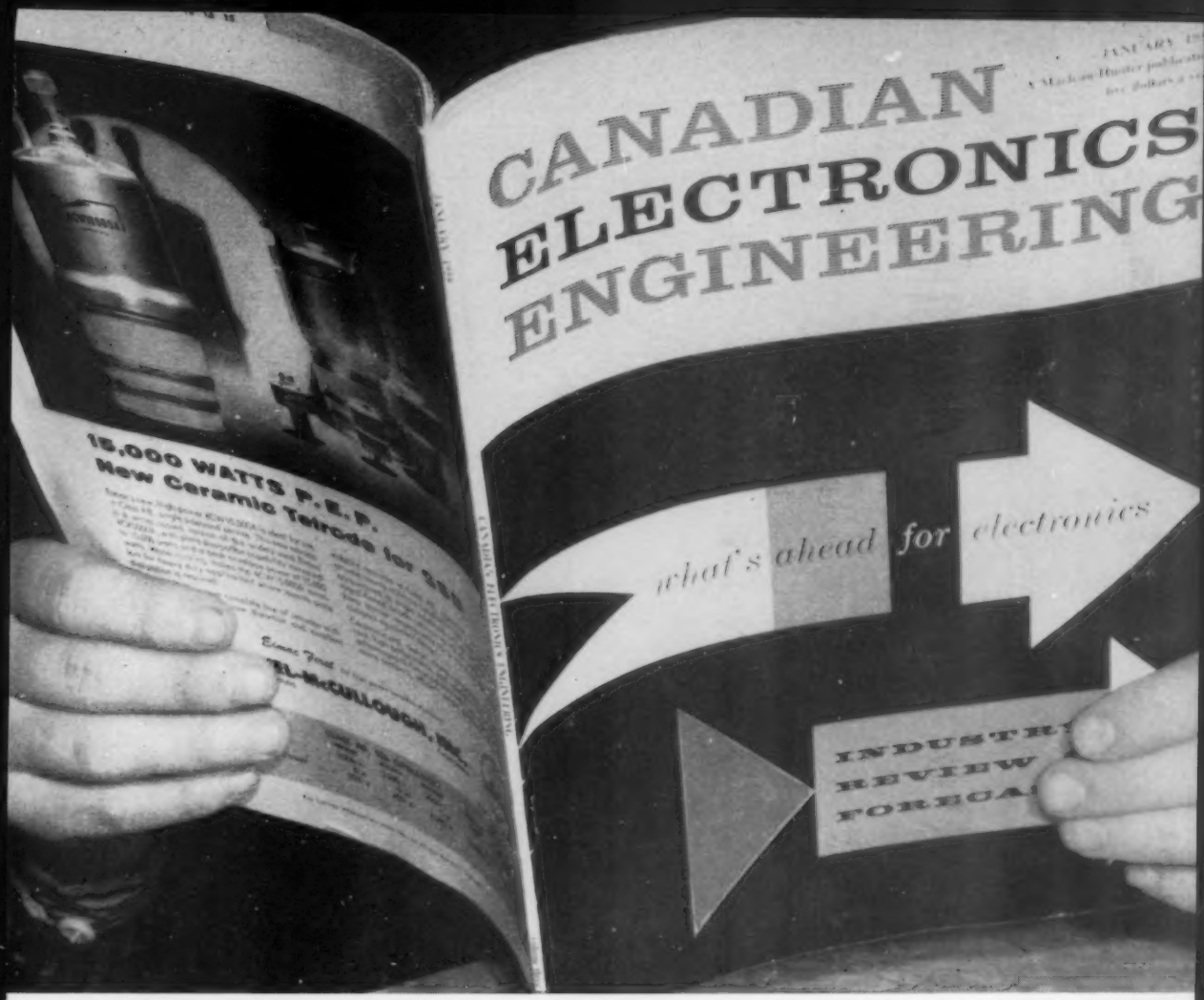
Philips Electronics Industries Ltd.,
Leaside, Toronto 17, Ont. - Montreal: 8525 Decarie Blvd.

Broadband mV-Meter GM 6012

Measuring range: from 1 mV (full scale deflection) in 12 steps up to 300 V; dB scale −80 dB up to +52 dB (0 dB = 1 mW into 600 Ω)
Frequency range: 2 c/s – 1 Mc/s
Input impedance: 4 – 10 MΩ//20-10 pF
Overall accuracy from 20 c/s to 100 kc/s: 2.5%; elsewhere 5%
Mains supply: 110-245 V, 40-100 c/s
Built-in calibration voltages
Amplifier can be used separately; gain 35 dB
5" linear scale with mirror reading

Quality, reasonably priced

For further information mark No. 49 on Readers' Service Card



SELL MORE IN '60

START BY ADVERTISING IN CEE's JANUARY

REVIEW & FORECAST NUMBER

In January 1960, Canadian Electronics Engineering will publish its Annual REVIEW & FORECAST of Canada's electronics industry . . . a comprehensive report made to all Canadians in electronics and its allied fields.

Because the REVIEW & FORECAST NUMBER will be packed with authoritative information on past, present and future electronic development, this important January issue will be awaited with more than usual interest by our readers. They are the people in Canadian industry who buy and specify electronic equipment.

Take advantage of this timely opportunity to sell these people by reserving advertising space in the REVIEW & FORECAST NUMBER—now!

Serving the electronics industry
— in management,
research, design and application

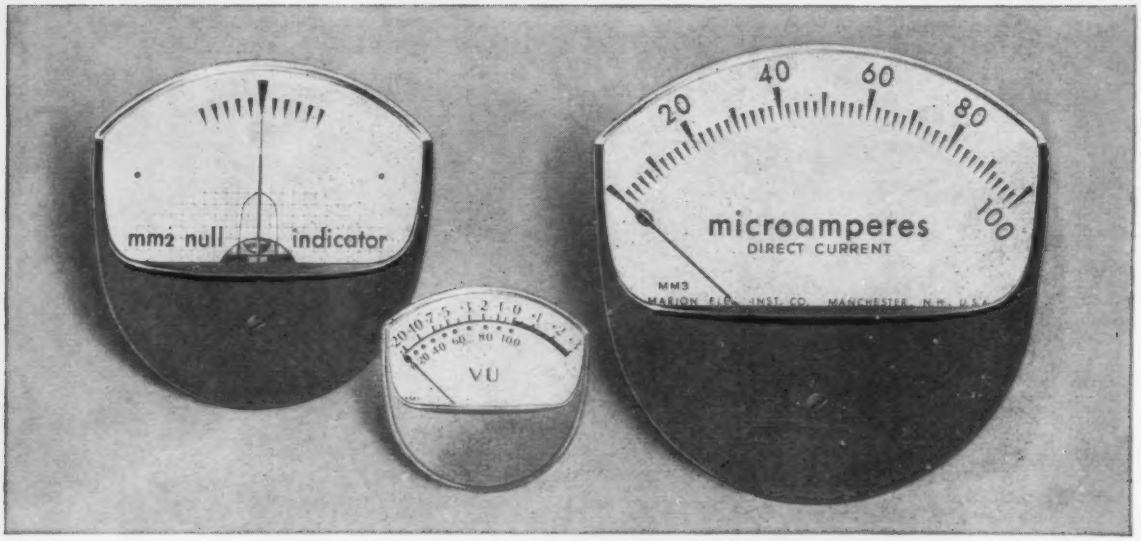
481 University Avenue, Toronto 2

CANADIAN ELECTRONICS ENGINEERING

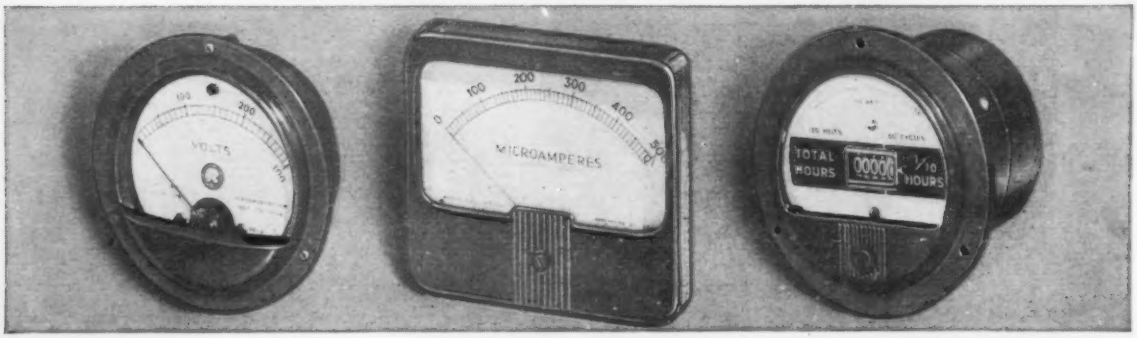
A MACLEAN-HUNTER PUBLICATION

NOW AVAILABLE THROUGH HONEYWELL

marion electrical indicating instruments



MARION MEDALIST* METERS—ammeters, voltmeters, VU meters and null indicators—are panel instruments of advanced design, providing greater readability and modern styling in minimum space. Available in 16 standard case colors, or custom colors to match your equipment.



MARION RUGGEDIZED PANEL INSTRUMENTS are specially designed to withstand the most severe requirements of shock, vibration, stress and strain. They are hermetically sealed and immune to hazardous climatic and atmospheric conditions.

MARION STANDARD PANEL INSTRUMENTS for commercial applications provide improved performance at moderate cost.

MARION ELAPSED TIME INDICATORS, in hermetically-sealed or bakelite cases, record running times in maintenance programming, productivity and utilization studies.

Marion Electrical Indicating Instruments are the latest additions to the growing line of indicating, recording and controlling instruments available from Honeywell. Marion offers eight basic groups of electrical indicating instruments and related products, incorporating the most advanced design concepts and production techniques. For further information, write Honeywell Controls Limited, *Precision Components Division,* Toronto 17, Ontario.

**Trademark*

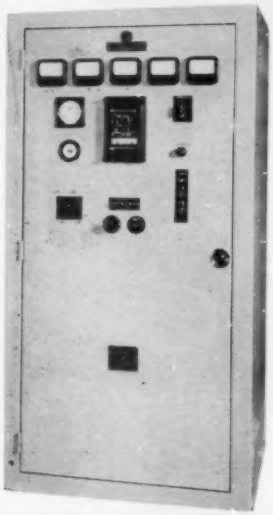
Honeywell

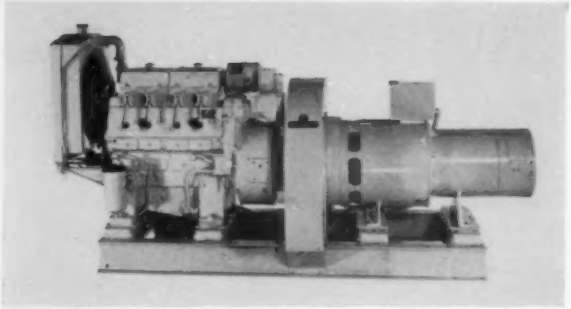
H marion meters

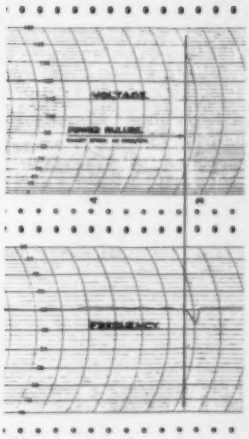
For further information mark No. 41 on Readers' Service Card

precise electric power to customer specifications

Mechron automatic no break and primary power diesel generating equipment







MECHRON NO BREAK DIESEL GENERATORS

maintains the voltage constant with negligible frequency droop when primary power fails

MECHRON NO BREAK DIESEL GENERATORS ARE AVAILABLE TO MAINTAIN EXACT SYSTEM FREQUENCY WITHOUT FREQUENCY DROOP DURING PRIMARY POWER FAILURE

MID CANADA LINE

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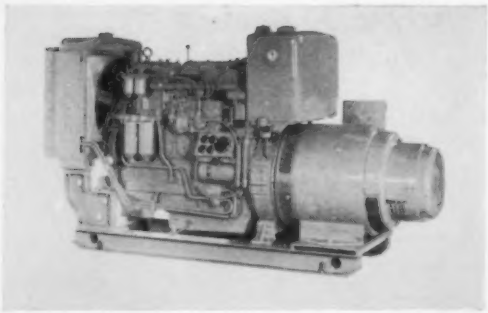

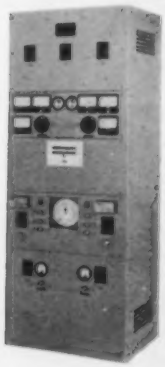

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The EC157 triodes offer many desirable features – peak performance, dependable service and outstanding uniformity from tube to tube.

TECHNICAL DATA

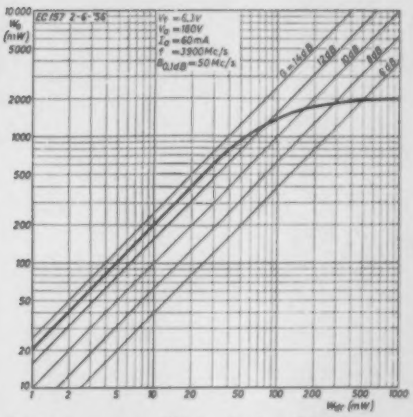
HEATER	V_h = 6.3 V					
	I_h = 0.73 A					
TYPICAL CHARACTERISTICS		nom.	min.	max.	nom.	
Anode voltage	V_a =	180	–	–	180	V
Anode current	I_a =	30	–	–	60	mA
Grid voltage	V_g =	–2.8	–4.0	–1.8	–1.6	V
Mutual conductance	S =	17	13.5	–	19	mA/V
Amplification factor	μ =	43	33	52	43	

OPERATING CONDITIONS
AS GROUNDED GRID AMPLIFIER AT 4000 Mc/s

Anode supply voltage	V_{ba} =	200 V
Grid supply voltage	V_{bg} =	+20 V
Cathode bias resistor	R_k =	max. 500 Ω
Anode current	I_a =	60 mA
Bandwidth (0.1 dB down)	B =	50 Mc/s
Output power at 8 dB power gain (V_f = 6.3 V)	W_o =	1.8 W (min. 1.5 W)

MAXIMUM RATINGS (absolute maxima)

Anode voltage at zero anode current	V_{ao} =	500 V
Anode voltage	V_a =	300 V
Anode dissipation	W_a =	10 W
Cathode current	I_k =	70 mA
Grid current	I_g =	10 mA
Driving power (grounded grid)	W_{dr} =	1 W
Direct grid voltage (positive)	V_g =	0 V
Direct grid voltage (negative)	V_g =	–50 V
Heater to cathode voltage	V_{kf} =	50 V
External resistance between cathode and heater	R_{kf} =	20 kΩ
External resistance between grid and cathode	R_{gk} =	25 kΩ
Anode seal temperature	t_a =	150 °C
Grid seal temperature	t_g =	75 °C
Cathode seal temperature	t_k =	75 °C



Output power (W_o) of the EC157 as a function of the driving power (W_{dr}) with lines of constant power gain (G); (f = 3900 Mc/s. $B_{0.1\ dB}$ = 50 Mc/s, V_a = 180 V, I_a = 60 mA).

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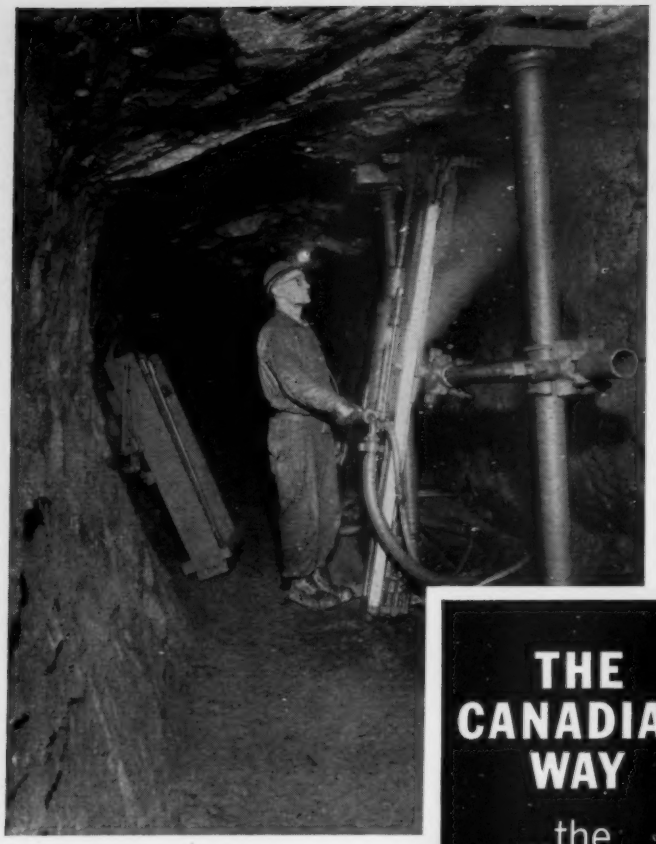

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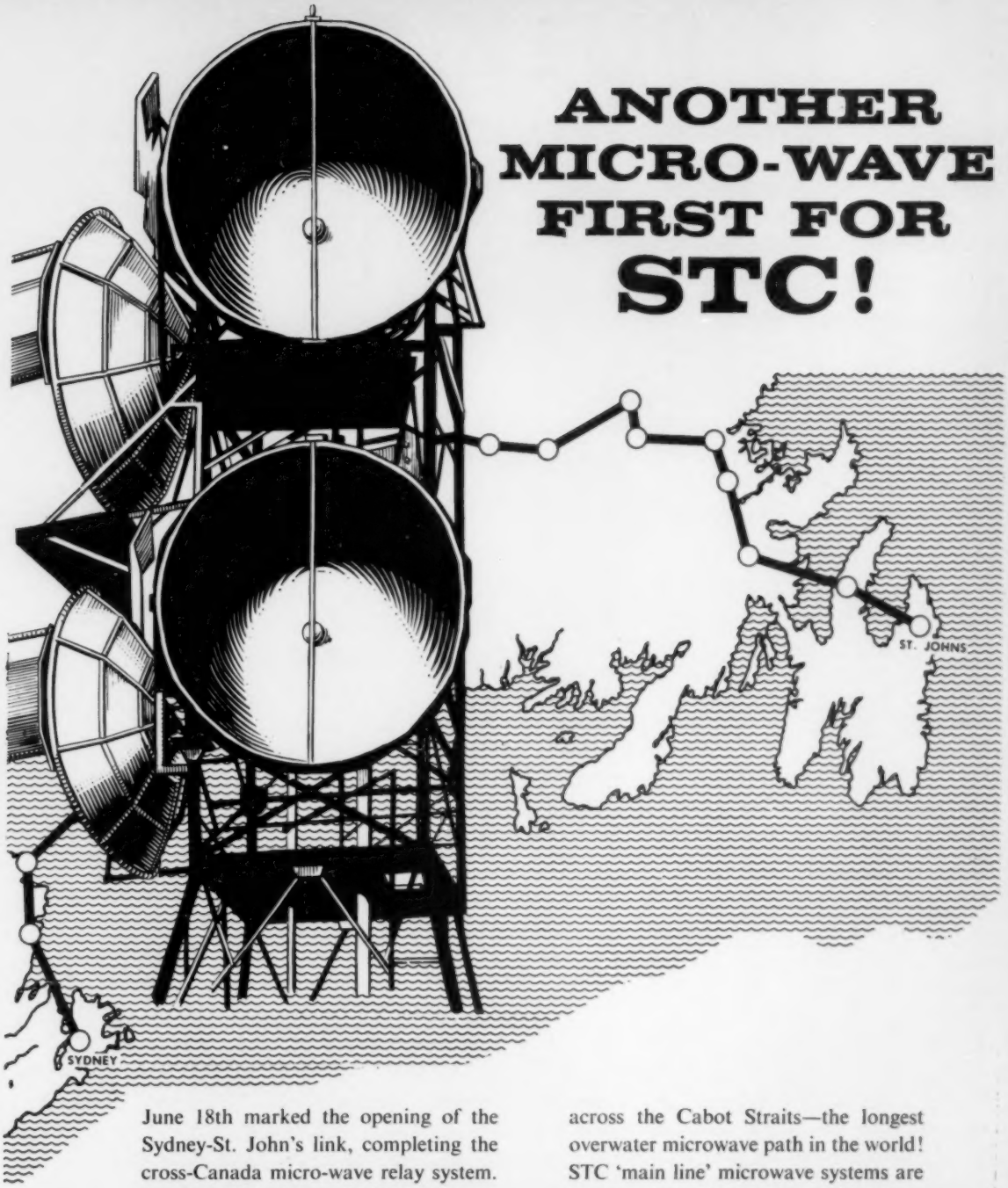

June 18th marked the opening of the Sydney-St. John's link, completing the cross-Canada micro-wave relay system. Standard Telephones & Cables' inventions and techniques made possible the successful spanning of the 69-mile hop across the Cabot Straits—the longest overwater microwave path in the world! STC 'main line' microwave systems are in operation all over the world. There are now over 1000 route miles in Canada!

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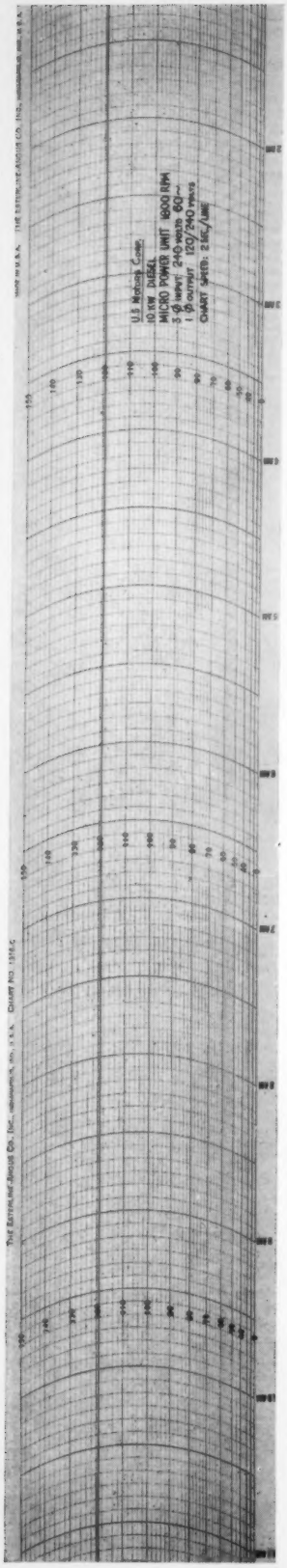
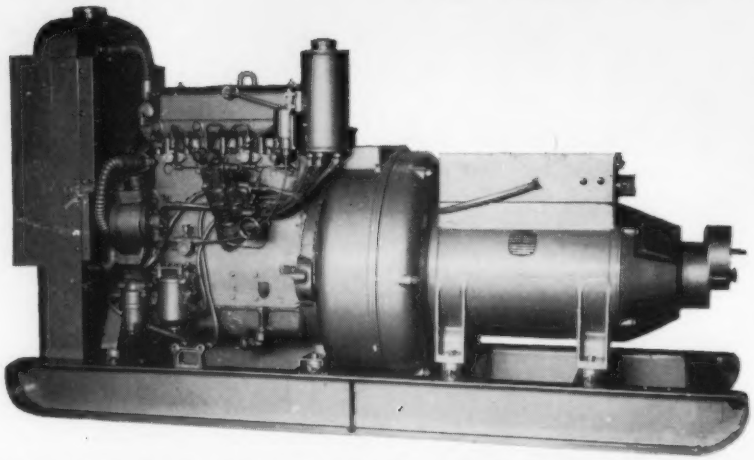


PUZZLE:

FIND THE POWER BREAK



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THE GRAPH reproduced on this page shows an actual voltage record during a power interruption from normal source — and protected by the new lightweight 10 KW U.S. Motors *DIESEL* "Micro Power" no-break generator.

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Microwave communications in Canada

Canada could not have become a Dominion spanning the North American continent from coast to coast without railways to join its eastern and western extremities. Nor could its phenomenal growth in the twentieth century have been achieved without the development of the continent-wide telegraph and telephone facilities so vital to our business and industry.

The need for these communication services steadily increased to levels well beyond the capacity of existing wire line, cable and hf radio systems. Microwave radio has therefore been called upon to meet the demand, not only for voice and message circuits, but also to make possible the economical operation of national radio and television networks.

Over the past decade several thousand route-miles of microwave systems have been put into service, culminating last summer in the completion of the final link of the Trans-Canada Telephone System chain between St. John's, Nfld. and Victoria, B.C.

Recognizing the importance of these developments, CEE has devoted this issue to the subject of Microwave Communications in Canada. Its timeliness is indicated by the current news of yet another major addition to Canada's microwave facilities, the Alaska link (see page 9).

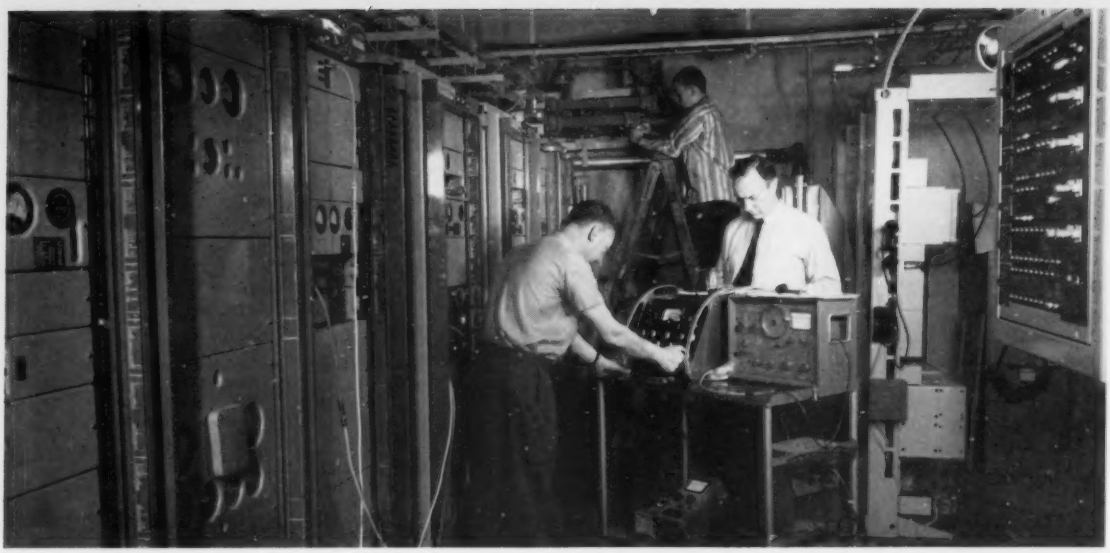
The first three feature articles have been contributed by representatives of the main groups of users of microwave equipment: communications companies, telephone companies and public utilities. These are followed by discussions of the equipment itself, emergency power supplies, antennas and radiating systems, towers and passive repeaters. The final article gives an indication of the tremendous potential for expansion as Canada's resources are further developed.

Starting on page 43 is a table containing a comparison of the specifications and performance characteristics of 32 microwave relay equipments and systems now available from the manufacturers. We believe this is the first time that so comprehensive a comparison has been published, and trust that it will prove of interest and value to our readers. Thanks are due to the manufacturers and representatives who co-operated by returning the questionnaires from which the table was compiled. It should also be mentioned that further equipments are available, the details of which could not be obtained in sufficient time.

Some difficulties arose during the formulation of the questionnaire and the compilation of the table which emphasize the need for greater standardization of the definition of certain parameters. These include particularly peak frequency deviation, receiver sensitivity, idle noise and intermodulation noise.

The Canadian Radio Technical Planning Board has done a lot of good work in promoting liaison between the manufacturers and the users. We are sure that continued and, where necessary, intensified support of its efforts will resolve these and other problems.

THE EDITOR



How a communications company looks at microwave

K. J. MacDONALD, P.ENG.*

Canadian National Telegraphs have made increasing use of microwave relay systems in providing a wide range of communications services. The considerations applied by CNT in system planning and choice of equipment are described. A plea is included for closer liaison between manufacturers and users, both during the early phases of system projects, and on a continuing basis with a view to greater standardization.

The development of Canadian National Telegraphs as a major public telecommunications firm in Canada has been marked by strong growth in two dimensions. An expanding volume of facilities has been needed to care for an increasing variety of communication services. The problems of providing more and more communication channels in every part of the nation have been met only by using new developments in the art to good advantage. Today, many of these problems are being tackled by the development of a nation-wide microwave network. Much of the network will be constructed in conjunction with the Communications Department of the Canadian Pacific Railway Company.

From a modest beginning a little less than a decade ago, when we first established point-to-point VHF radio systems, we have advanced to the most modern 2,000 and 4,000 megacycles microwave relay systems, capable of carrying a colour television program or up to 600 telephone channels on each radio channel.

At present, some 1,500 miles of radio relay system are in operation; another 1,500 miles of system are now under construction. The Communications Department of the Canadian Pacific Railway Company has joined with us in the construction and operation of about 950 of the 1,500 miles of microwave system now in service. Of the mileage now under construction, 300 miles of system will be jointly owned and operated.

To gain a better idea of the variety of communication channels which must be provided for in our microwave relay planning, we might examine the growing list of services available to CN-CP customers. Telegraph channels must be furnished for both public commercial and Private Wire Services, as well as for Telex, the popular automatic teleprinter exchange service. In addition, many telephone channels are required for public and private long-distance use, including special networks for government depart-

*Assistant General Radio Engineer, Canadian National Telegraphs, Toronto.

ments and military needs. Program network facilities are needed for both television and radio broadcasting. Some specialized services include channels for facsimile and wirephoto, data transmission, and control and telemetering applications. We must also provide channels for a wide range of communication services for the operation of both the CNR and the CPR.

Conditions differ for each type of service

The transmission requirements for these different services vary considerably. A little thought will make this clear. The television signals require much more bandwidth at substantially uniform gain than any of the others. Somewhat higher levels of background noise can be tolerated by carrier telegraph signals than we should find acceptable for long distance telephone service. The application of compandors to telephone channels can, of course, reverse this condition.

On the other hand, serious errors in carrier telegraph signals may be caused by occasional high level impulse noises or by short interruptions, such as those created by radio baseband switching in diversity arrangements. The same noises or interruptions may constitute no more than a mild nuisance in speech transmission, with negligible effect on intelligibility. Of course, impulse noise will usually be much more serious on data transmission systems employing several pulse levels than it is in telegraph systems using a binary code.

When a combination of several different kinds of communication channels is to be borne on an essentially wide-band facility such as microwave provides, the limiting transmission factors generally are the system noise and distortion levels. The type of service having the most stringent requirements as to noise and distortion will thus determine the system performance requirements.

Microwave systems need high standards

In planning trunk route microwave systems, CNT and CPR engineers have used as a guide the CCIR/CCITT performance standards. The planning of microwave links forming parts of such trunk routes has recognized the need for high standards of noise and distortion performance in individual links if acceptable transmission is to be realized over these long-haul routes as future extensions are added.

However, CN-CP applications of microwave have not been restricted to long-haul main-line service. A number of short- to medium-haul links have been provided for television network service. Studio-transmitter type links have been employed for short extensions from our radio relay terminals to television studios. Some medium-haul systems will be established for telephone and telegraph communications to areas not served by our main routes.

There are always difficulties associated with the choice of radio relay sites for a given system linking two terminal locations. It is necessary to keep the performance objectives, including transmission reliability, in view while attempting to strike the best balance between first cost and probable future operating costs. Each new system planned will present a number of alternatives which must be weighed carefully by the engineer with a view to realizing full value for present and future dollars spent on the construction and maintenance of the plant.

The choice of microwave equipment for a particular system also involves this process of economic and technical evaluation. The user cost of a complete system designed and built to specifications for a given application may be prohibitive. Whenever a microwave system project offers the possibility of a choice of equipment, proposals submitted by a number of prospective suppliers may be compared and a relative evaluation carried out to determine which proposal promises the best value in terms of present and future costs versus performance. If the equipment covered by the most favorable proposal can meet the performance objectives set by the engineer, the choice is then resolved from his point of view. In some cases, these objectives can not quite be reached, and some soul-searching may be required before the engineer can recommend to management the additional cost for better performance.

This sort of evaluation often depends upon comparison of calculated performance for systems with which the user has had no experience. In addition, various manufacturers do not use identical methods of calculating system performance in terms of noise and distortion. In some cases, the basis of the calculation is not made clear in the proposal, so that the engineer is severely handicapped in attempting to work out a relative evaluation. Re-calculating performance on a like basis for several proposed equipments may be rather laborious.

The solution to this last difficulty, and some others as well, may perhaps lie in greater efforts by both manufacturers and users to work through associations such as the Canadian Radio Technical Planning Board toward a greater degree of standardization in the microwave field.

It has been our experience that our more successful and satisfying microwave system projects have been marked by good, close liaison between our engineers and those of the manufacturers. Projects flow with greater smoothness, and fewer misunderstandings, when we have been able to establish satisfactory communications with the supplier's engineering staff from the beginning. We feel that the benefits to be obtained in this way deserve to be more widely recognized.

This is not intended to be a plea for less emphasis on sales engineering. It is, however, a call for improved liaison with the design, production, and development engineers, who are often best equipped to deal directly and frankly with the customer's engineers on many questions. A good number of questions of concern to the customer arise in the early stages of a system project, even before he is committed to a particular choice of equipment.

The next ten years for Canadian National Telegraphs hold prospects for a manifold increase in the volume of communication channels borne by microwave systems. The task ahead is one which our engineering and operating forces will be pleased to share with those manufacturers of microwave equipment who can be helpful to us in our aim to develop economical and reliable communications to serve all Canada. END

Canadian National Telegraphs installed communications system for Gander airport. It provides weather data link, voice communications with aircraft, and links with other airline offices by telephone and teletype.

Adapting radio equipment for telephone companies

J. C. D. MALLET-PARET, P.ENG.*

The rapid growth in the use of radio facilities by the member companies of the Trans-Canada Telephone System has led to some problems in adapting radio equipment for telephone company use. Recommendations are made in the areas of equipment packaging, jack fields, instruction manuals, choice of components, and the specification of equipment parameters.

Within the past five or six years Alberta Government Telephones have added extensive radio facilities to their system and are now, along with all member companies of the Trans-Canada Telephone System, engaged in radio activities of various forms on a scale never before equalled. Microwave, mobile radio, private leased radio, scatter, dispatch, television and point-to-point systems are all becoming commonplace in telephone company operations.

In entering the realms of higher frequencies the telephone companies have experienced some difficulties in adapting themselves to the new medium. This should perhaps be rephrased to say that the telephone companies have had some difficulties in adapting radio to the telephone medium. In any case, radio and the telephone company have entered a period of mutual adjustment, and it would appear that the two are now complementary.

Before outlining some of the technicalities involved in adapting the medium to telephone company use, it is necessary to make clear the approach of the company when employing radio as a communications facility. The Trans-Canada Telephone System, as is well known, is made up of eight major companies; it must therefore be assumed that a variety of approaches prevail. Some of these companies are large and have engineering departments with much experience gained through affiliation with other companies. Others are small and less experienced, and indeed rely heavily upon help from the supplier. Some are privately owned and are accountable only to their boards of directors for policies concerning business dealings with the manufacturers, while others are departments of provincial governments and are obliged to respect the practices of governmental tendering in order to justify proper expenditure of public funds. Some operate in heavily populated areas and serve mainly urban centres, while others find that they must gap many miles of non-revenue-producing territory in order to serve an isolated community.

Because of these differences it could be expected that the techniques of purchasing equipment and the technical requirements of the equipment must vary between companies. Nevertheless, the members of the Trans-Canada Telephone System have a uniformity of purpose: to provide a uniform transmission medium from one company to another in order to make available the Trans-Canada Telephone facilities. This purpose is not only basic to the Canadian companies but is also essential for interconnection to telephone facilities throughout the world.

In order to achieve this goal of uniformity it has been necessary to develop, over a period of years, design philosophies that encompass standards of transmission, operation and reliability, and it is the responsibility of each company to attain such standards. Historically many of these standards have been developed for wire line and cable facilities and must now be employed directly when radio facilities are used. Quite often the radio facilities can meet or exceed by far the original standards and in other respects they may fall short of achieving the goal. At any rate, all radio equipment must be employed in a manner that will satisfy telephone standards.

Too often in the past have well-meaning suppliers of radio equipment plunged headlong into the telephone business and attempted to interest the telephone companies in equipment that was designed for the military, utilities and other services. They were unable to understand the apparently dogmatic attitude of telephone engineers in

*Radio Systems Engineer, Alberta Government Telephones, Edmonton.

refusing to accept the equipment. However, this past experience seems not to have been in vain, since many suppliers are now catering to the whims of the telephone industry and are extremely helpful to many of the smaller, less experienced companies. The first steps of progress have thus been made by the radio manufacturer in adapting himself to the ways of the telephone companies. What are these steps?

Equipment packaging

First and most apparent is the repackaging of equipment in a suitable form for use in telephone offices. The telephone companies have well-established toll offices which are laid out in a manner equally well established. It is therefore quite gratifying to purchase radio equipment that will fit into an existing equipment lineup, has suitable dust covers and in general looks like telephone equipment. Unfortunately, the problems of repackaging radio equipment are often not clearly understood by telephone engineers who are not familiar with radio equipment design. It therefore falls upon the supplier to justify the reasons for cabinet-type installations complete with RF plumbing, interconnecting coaxial cables and point-to-point wiring techniques. It is equally difficult to explain to the radio supplier that panel-type construction, on 11-ft-6-in. relay racks, with inter-bay wiring properly laced up the side of the rack, and bay-to-bay wiring via overhead runways, is all extremely necessary for establishing an orderly growth of equipment in a toll office. Concessions must be made by both parties; however, judging by the successful attempts of some radio suppliers, it appears that repackaging of radio equipment to conform to telephone standards can be achieved.

The use of 19-in. relay rack panels, plug-in components, subchassis, and the liberal use of test points about the bay are all desirable. One specific adjunct to any type of packaged system that is frequently seriously underdesigned in radio equipment is the use of suitable jack fields.

Include jack fields

Jack fields have always been used extensively by the telephone industry for various functions. They are excellent test points and can be used for patching one system to another for purposes of maintenance routining or restoration of facilities. They are monitoring points and are often used to terminate facilities. They are also extremely useful for isolating or by-passing equipments while attempting to track down faults. Without jack fields the telephone plant would be an extremely difficult machine to maintain.

While it is understandable that rf frequencies are difficult to handle on jacks and cords, there have been a few successful i-f patching arrangements developed on microwave facilities that provide a good flexibility in system operations. At the baseband frequencies, line, drop, and equipment jacks are absolutely mandatory in the eyes of the telephone engineer. Many radio systems have been installed in Canada on which jack fields have been added by the telephone company; thus it would seem that a system with standard jacks could quite easily be designed and supplied by the radio manufacturer.

Maintenance and test instructions

Jack fields are synonymous with testing, and testing, to the telephone maintenance forces, is synonymous with levels and maintenance practices. To say that radio men do not know how to test and line up their equipment would be absurd; however, it has been noted that the approach to line-up and testing in radio circles is somewhat different from that in telephone circles.

There are many schools devoted to training radio technicians. It would appear from the technical manuals supplied by most radio manufacturers that their instructions are written for use by the graduates of these schools.

In the telephone industry, nearly all employees learn their work on the job, accompanied sometimes by company training courses during their apprenticeship periods. In order to utilize such employees in their early years, test procedures are detailed in a clear and concise step-by-step manner, not for the purpose of immediate understanding, but with a view to obtaining a specific result when the step is completed. If the result of the test is not obtained then corrective action is indicated. Input levels for test signals must be clearly stated, methods for applying the signal suitably illustrated, and output levels quoted, together with their acceptable limits, test by test and step by step.

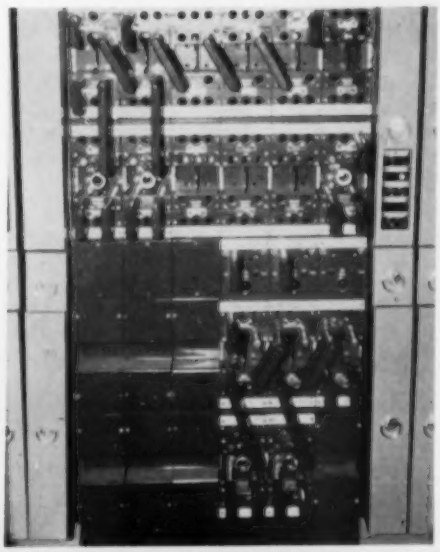
The use of this type of maintenance instructions over the past years has led the maintenance forces to expect nothing less: any instructions that are presented in other than this format are usually not acceptable. When the telephone industry begins to employ radio men to do radio work this specific type of instruction will not be necessary; nevertheless, there is much in favor of clear, concise instruction manuals.

Quality components

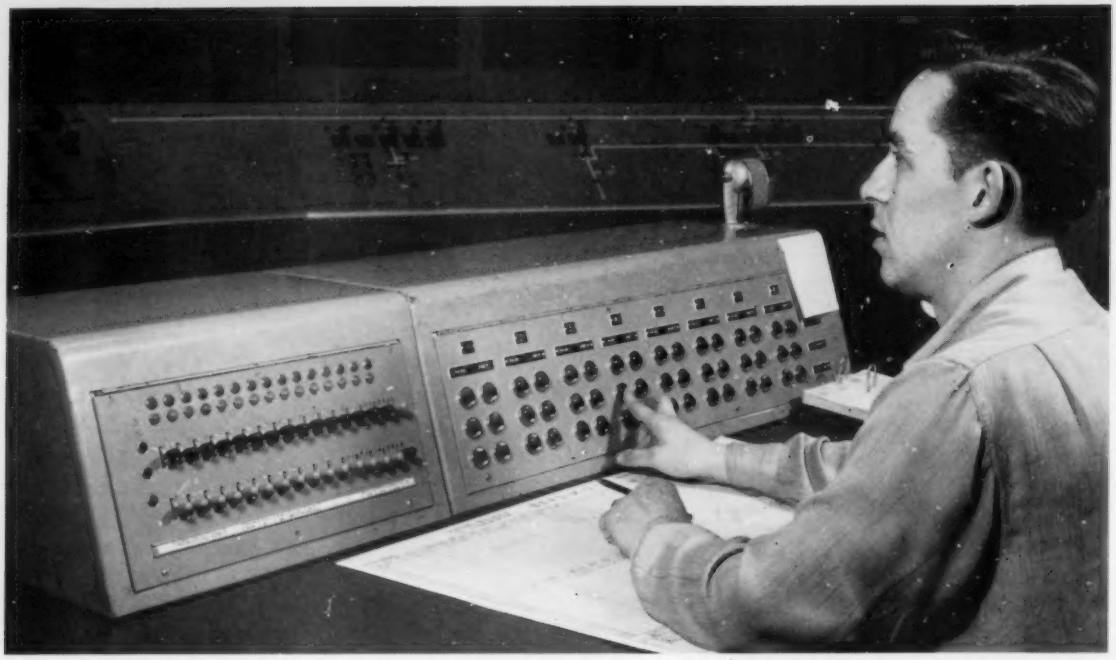
In the telephone industry much stress is placed upon the quality of components. In a switching system, for example, there are requirements for large numbers of each type of component, be it a stepping switch, relay, resistor, capacitor, or tube. In order to assure reliability of these hundreds of components in one office, great efforts are made to ensure that they are of the best quality, regardless of cost. Quality of components is also expected in radio equipment. There is no surer way of failing to obtain a repeat order than by supplying equipment that suffers a continual failure of components. Telephone engineers are used to high quality components, and are willing to pay for them in equipment that is expected to have a 15- to 20-year life.

To avoid a large inventory of stock items in the telephone maintenance stores, it is desirable to keep the number of types of components in any one system as low as possible, the use of common components is desirable. Much

(Continued on page 41)



Telephone engineers need jack fields in their radio equipment. This is a successful i-f patching arrangement.



Reliable radio links are vital to power utility operations

O. CARDELLA, P.ENG.*

Microwave radio has become an indispensable tool in the efficient operation of large public utilities such as Quebec Hydro. The utility engineer in turn demands high standards of reliability. Recommendations are made to both system planners and equipment manufacturers with a view to achieving even higher percentage availability.

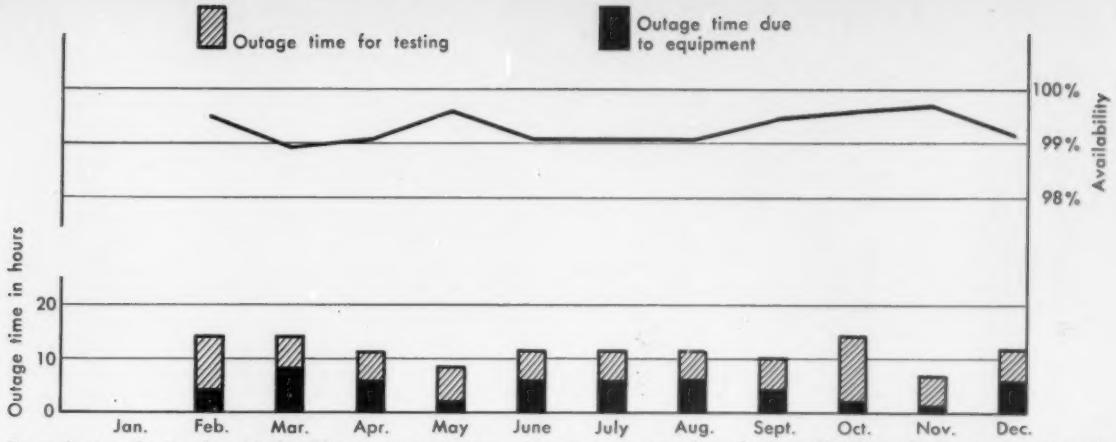
Five years ago, the power utility engineer was little interested in using the microwave system. He distrusted its reliability and was unimpressed by its multiplicity of channels. Today he depends on it in the efficient operation of his network.

While the war years saw a rapid rise in the demand for electric power by industrial users, the years thereafter saw a phenomenal increase in demand by all types of users: industrial, commercial and domestic. At one stage, customer requirements increased at the rate of 12% annually and the utility was hard pressed to increase its plant capacity at a high enough rate to keep ahead of the demand. The power engineer consequently drew up a long-term hydraulic development program based on the system planning engineer's estimates of load growth over the following twenty-five years.

As one part of the program, operating plants with still undeveloped capacity were to be extended to make full use of the available water. Secondly, potential sites were to be surveyed, mapped, tested in the model laboratory and, if economically feasible, finally constructed. Here, as a relatively small but necessary part of the program, communications requirements were determined. Apart from local communications within the power house site, long distance trunk lines to the head office were essential to carry operating information. Telemetering lines were also required to obtain at the system operator's office a continuous record of the plant's output. It was summarily decided in one case that the old standby — power line carrier—would be the medium to utilize.

A frequency spectrum chart soon showed, however, that the already crowded 50-200 kilocycles power line carrier band had little room for the required number of voice circuits for operation. Since the power house sites under study were far removed from civilization, it was planned to provide certain urban facilities such as shopping centres and theatres for resident personnel. This entailed administrative offices and also communication lines to the head office restricted to their use. At the same time, a study showed that for the long distances involved in the transmission of power to its destination, such high line voltages were necessary that line noise would be a serious factor to contend with in a power line carrier system.

*Control and Communications Design Engineer, Quebec Hydro-Electric Commission, Montreal.



Records for the Quebec Hydro-Electric Commission microwave system show high availability. However, power engineers have come to rely upon the system to such an extent that they now impose ever increasing premiums on reliability.

Power line carrier inadequate

It soon became evident in this case that power line carrier would fall short of providing the quantity and quality of communications services necessary for the efficient operation and administration of a remote power house. It also became evident that only microwave had the capacity and flexibility to handle the job and, moreover, had the advantage of being completely independent of the power lines and therefore not necessarily subject to outages at the same time, when it was most needed.

Specifications for the microwave system were based on the premise that the primary traffic to be transmitted would be voice with a permissible interruption of 30 seconds duration for either equipment or primary power failure, and changeover to standby. Telemetering, teletype and mobile radio were also included; here too an interruption of 30 seconds was deemed acceptable.

Now after three years of operation, the system has proved to be a dependable and flexible medium of communications in the service it was originally intended to render. So much so that as the power network expanded, the circuits increased both in number and in type, and imposed an ever greater premium on reliability. Today, in the light of the recent demands which the power engineer has made upon microwave communications, it is felt that certain original specifications should bear revision in a future system.

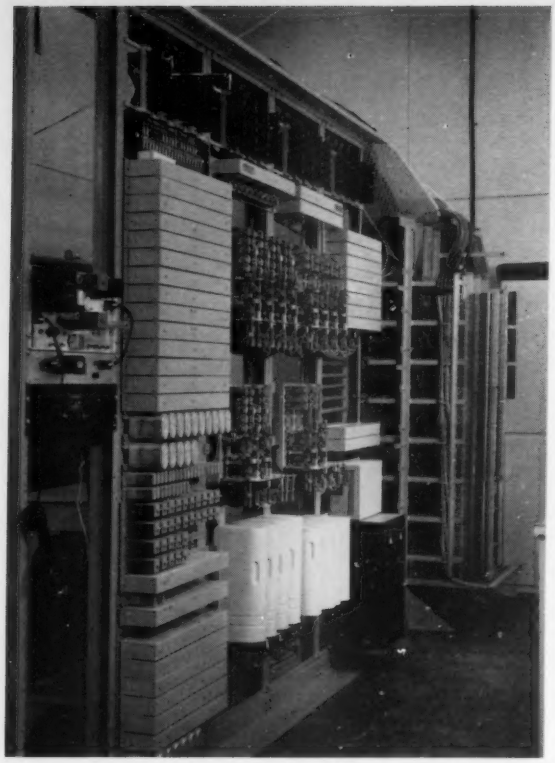
In order the better to analyze these changes, they are listed below under several headings, each indicating the area in which revisions are suggested.

Power source. The continuity of service required by a modern power utility rules out the use of any but a no-break emergency power source. With the growth in size and complexity of the power system, there arises the need for load-frequency control, protection and synchronizing pulse circuits over and above voice and telemetering. Within the near future, facsimile, fault locator pulse timing, voltage phase difference measurement, transfer trip, data logging, and system loading computer circuits with their characteristic requirement of continuous error-free operation, may be added to the roster of facilities to be carried.

Even momentary interruption of service on failure of the regular source is not acceptable. If the microwave system is three or four hundred miles long, many of the repeater stations will probably be located in isolated areas fed by long rural power lines subject to frequent outages in the winter. To cite one case on record, a diesel-generator set was called upon to deliver "standby" power for 20 hours a day for six consecutive weeks during a severe cold spell when the water feeding a small hydraulic plant in a rural community almost completely froze over.

There are two common methods of obtaining no-break power. One involves a continuously running three-machine set consisting of a generator driven by a motor connected to the regular supply and on the same shaft, a flywheel, a clutch and a diesel engine. A more elegant method uses batteries, a charger and a diesel-generator set for charging the batteries during power failure. Since there are few, if any, manufacturers offering microwave equipment operating directly from batteries, this necessitates the use of inverter power supplies, preferably transistorized to take advantage of their inherently low losses. With such power supplies provided in duplicate, supply power reliability would be assured.

Power lines feeding isolated stations are subject to outages. Standby power equipment must be reliable.



Power house dial trunk equipment such as that shown above requires low-noise circuits for correct signalling.

Recent developments in battery charger control, in particular those employing magnetic amplifiers and Zener reference diodes, allow paralleling and equal sharing of load of two chargers and also free operation of one charger when the other is in trouble.

It may be mentioned that manufacturers should provide built-in static regulating transformers in ac-operated equipment, preferably 50% overrated. Both the regulating transformer and the microwave equipment should be capable of operation over a power frequency range of 55 to 63 cps. As a further suggestion, particular care should be taken to isolate the equipment room from engine noise, fumes and vibration. Ideally, the rotating machinery should be located in a separate building but the higher cost involved precludes this idea.

Microwave equipment. As originally specified, cold standby equipment with a 30-second warm-up and changeover time was installed. For the reasons of continuity of service stated previously, this was soon converted to hot standby with split-second changeover time.

This is not quite enough, however. High reliability services such as transfer trip protection and synchronizing pulses require that the changeover time be reduced to zero. This calls for a diversity system with electronic mixing of two signals. If frequency diversity is not licenseable for power utility use, then one must go to space diversity.

To the extent that they are available to replace standard type tubes, high-reliability long-life tubes should be included throughout the equipment. Also, pre-ageing of standard type tubes helps reduce maintenance trips.

System performance. Fading over single hops during calm summer days, particularly in August, may interfere with some types of service. It is suggested that the fading margin should be at least of the order of 40 db, providing a system reliability of 99.99%; an additional allowance of 6 db would also protect against the effects of deterioration in the performance of tubes or other components of the equipment.

Where microwave circuits carry pulse trains, particular attention should be paid to basic noise level. Depending on the length of the system and on circuit loading, and also on the economics, it is felt that a noise level of 30 dba (55 db signal-to-noise ratio) should be specified.

Survey. It is recommended that the prospective buyer of microwave equipment procure a complete survey of the proposed route showing the profile of the highest peaks and the results of tests over each hop. The tests should be carried out either by the visual line-of-sight method (spotlights at night), or preferably by radio at the frequency of the proposed system.

Multiplexing equipment. Only toll quality multiplexing should be specified. One may even go further and say that top toll quality should be seriously considered—the dividends of greater stability and lower maintenance will offset the extra capital cost incurred.

All stations which include multiplexing units should be equipped with adequate jack fields for easy and fast testing.

In those cases where a microwave station is situated on a hard-of-access mountain top and is at the same time not too distant from a permanent building at the bottom of the mountain, the multiplexing equipment should be located at the bottom where it can be maintained more easily and quickly. Since there are more service calls and time spent with multiplexing racks than with microwave racks, the technician will be spared some arduous trips up the mountain. In some cases the building at the bottom may be the power house itself. Of course, high-frequency cable is necessary to bridge the multiplex and microwave equipments; the lengths of this cable will determine the feasibility of this arrangement from the standpoint of losses and vulnerability.

Multiplex equipment should meet international standards on frequency allocations and signalling so as to facilitate interconnection between systems. Equipment common to more than one channel should be kept to a minimum. For instance, separate power supplies for each two or three channels result in a higher over-all reliability than one power supply for twenty channels.

Towers. The design of the towers should be left in the hands of experienced design or consulting engineers who specialize in this field. Design criteria will vary with the locality, but in eastern Canada, according to data available from the Climatological Map of Canada, the tower loading should be taken as one inch of ice coinciding with a 30 pound per square foot wind pressure. This of course includes a fair margin of safety. It is expected that weather conditions approaching or perhaps surpassing these in total loading will occur about once every twenty years.

Even where D.O.T. regulations do not require it, towers should be painted international orange and white, and lighted with a minimum of two 60-watt lamps. This applies particularly where there is any amount of bush flying.

Buildings. The design of these is also better left to a specialist—the architect. He will insure an adequate design, specify the insulation and heating compatible with local weather conditions, and arrange the foundation so that the pounding of the diesel engine will be taken by its own solid base and not transferred to the rest of the building.

Storm winds on a mountain top can drive snow through

the smallest of cracks around a door; a windbreak or at least a double door should therefore be provided. The former is recommended in order to keep the door clear of snowdrifts.

Roads. There are at present two schools of thought on what the quality of access roads should be. If the road is to be kept open the year round to passenger-type vehicles, then it should be built wide with adequate drainage and large-size culverts, and must be cleared of snow at every storm. However, capital and maintenance costs may run high, and it appears that it may be more economical to build more modest roads suitable only for four-wheel-drive vehicles such as jeeps. In the winter, instead of clearing the snow, snowmobiles or even heavier tractor-tread vehicles may be kept available or rented. With the heavy snowfall encountered in eastern Canada, snow-clearing is an expensive item of maintenance.

Maintenance. When a utility buys a microwave system for the first time and decides to undertake its maintenance, it might be better to request a package maintenance deal from the manufacturer to be included in the purchase price of the system. The utility's technicians should first be given a course on microwave theory of about two or three weeks length, then instructed in the particular features of the equipment being bought. They should follow, and actively participate in, the installation, tuning and commissioning of the system. Finally they should be entrusted with the maintenance of the system, but under the guidance of experienced microwave technicians for at least six months. Although each man may service only a section of a system, he should be made to realize how important his service is in relation to over-all system performance.

The microwave system has earned its place in power system communications. It is adaptable and flexible. It is used to transmit intelligence in several forms to serve the needs of both operating and administrative personnel. The operating engineer, however, insists on a higher figure of percentage availability and it is in this direction that he hopes the manufacturers will make a definite effort. END

IRE Canadian Region Gold Medal

The Institute of Radio Engineers Canadian Region committee has decided to establish a new award which will be the highest award in Canada for achievement in the field of electronics engineering.

The medal is to be given for technical or administrative contributions of well-recognized merit in: (a) research and development; and (b) applications in industry, government or education.

In general, the award will be made for achievement related to work done primarily in Canada and the award will not be given if a suitable candidate cannot be found for that year. Recipients need not be members of IRE.

Selection of the awardee will be the responsibility of the IRE Canadian Region committee, based on names submitted by a sub-committee. The recipient of the medal will be given a certificate with an appropriate citation which will be a brief reference to his major contributions to electronics.

Adapting radio equipment for telephone companies

(Continued from page 36)

telephone equipment, such as multiplex, is specifically designed to provide as many identical sub-units as possible. It would seem that similar efforts could be made in the design of radio equipment. For example, a line of equipment might be developed with common power supplies but interchangeable rf, i-f and baseband assemblies.

Equipment parameters

The most important step in the choice of equipment for specific applications is, of course, the evaluation of equipment specifications and parameters. Because these parameters are linked so closely with the particular systems design it is not possible to generalize on what is acceptable. However, there are specific and acceptable limits in each case. The following are a few examples.

For antenna systems one must consider wind loading, heating and pressurizing systems, VSWR vs. frequency, gain vs. frequency, return loss, intermodulation, side lobes, horizontal and vertical polarization discrimination, beam width, front-to-back ratio, tower loading, possible weather damage, characteristics of isolators, and the arrangement of channel filters for multichannel systems related to their ultimate expansion.

For transmitters it is necessary to consider the frequency range, power output, stability, stability control features, rf bandwidth characteristics, nominal deviation for various loads, nominal load characteristics, input levels and impedance, pre-emphasis characteristics, intermodulation characteristics, and power requirements.

For receivers, consideration must be given to the receiver noise figures, threshold level, frequency range, frequency stability, limiting and agc action, spurious response, output levels, impedance and other characteristics.

When laying out a microwave route the systems planner must consider frequency range, proposed switching and standby methods, alarm facilities, order-wire facilities, and the future orderly expansion of the system. Many suppliers of multichannel microwave systems have failed to provide a co-ordinated growth plan which clearly illustrates the methods of adding additional channels. This type of information is extremely useful in attempting to co-ordinate one type of radio system with another. With the rapid growth of radio in the telephone industry, co-ordination problems are becoming more and more important.

It is not possible to discuss here the effects of these parameters on systems design; however, it should be noted that detailed information covering these parameters is necessary for proper systems computations. Suppliers who can produce such information are more favorably received than those who cannot, since the buyer can see that effort and thought have gone into making the product suitable for telephone company use.

Fortunately committees now exist within the framework of the Canadian Radio Technical Planning Board and other organizations that are dedicated to the guidance of manufacturers and buyers in the problems faced by both parties. The Microwave Task Force and the Scatter Committee can assist manufacturers in thinking along the same lines as telephone companies. It is believed that the formation of these committees substantiates the feeling that, if radio equipment is to be used for telephone service, more efforts are necessary to make it acceptable for telephone use. It is also the responsibility of the telephone companies to provide the necessary guidance for the successful achievement of this goal. END

Equipment reliability — the key to system reliability

J. R. SIMPSON, MEM.I.R.E.*

The reliability of microwave radio relay equipment is defined in terms of "survival probability" and "performance reliability." The factors that contribute to these two aspects are examined in detail, and the further improvements to be achieved by diversity operation are described. The importance of preventive maintenance is also mentioned.

The probability that a device, equipment or system will perform its intended function for a specified length of time under given conditions — this is reliability. The definition is a broad one, but it lends itself to analysis in the light of the various connotations of the term. To some people, reliability implies a "go-no go" probability which is related to system outage, due either to equipment failure or to abnormal external conditions. The "will perform for a specified length of time" portion of our general definition applies here. To others, reliability is taken to mean the provision and maintenance of a given grade of service — the "its intended function" part of our definition. The ultimate objective is, of course, to provide maximum reliability in both these connotations. Something will be said later about the "under given conditions" expression, which affects reliability no matter how you choose to define it.

The probability that a system will perform for a specified length of time may be called "survival probability." To the extent that it is controlled by the equipment itself, survival probability has been the object of a great deal of attention in recent years, most of it by, or on behalf of, military agencies. Studies have been carried out to establish parts and design standards, and to formulate methods for the statistical prediction of survival probability. The importance of achieving maximum survival probability in the military field is easily appreciated, considering our dependence upon electronics for defence. Unfortunately, even the most generalized of the military standards and methods are often disregarded when equipment is being selected for commercial applications, although in some cases our dependence upon the equipment in question is significant, albeit less dramatic.

One of the applications of electronic equipment upon which we depend a good deal is the microwave radio relay system in telephone and telegraph service. The tremendous increase in the amount of traffic being routed over microwave systems each year, and the certainty that this increase will continue, render it imperative that equipment reliability be carefully considered; the communications companies, who are experts in reliability from way back, are doing just that.

Survival probability

In the majority of cases, the standards applied to military equipment and the methods used to guarantee a given survival probability cannot be used in the commercial field, for purely economic reasons. An uncompromising approach to equipment design and manufacture, often justified in military applications, is rarely possible for the

(Continued on page 47)

*Radio Systems Specialist, Automatic Electric Sales (Canada) Ltd., Toronto.

Manufacturer's Name and Address (See note 1)	Model No. and/or Name	Frequency Range (mc)	Type of Modulation (2)	Channel Capability and Type (3)	Transmitted RF Bandwidth (mc)	Peak Frequency Deviation	
						A (4)	B (5)
Brown Boveri & Co., Baden, Switzerland (Brown Boveri (Canada) Ltd., 1015 Beaver Hall Hill, Montreal)	RT 1646A	375–425 450–470	PM	1 V	0.03	6db/0, 0.3-3.4kc; 12/1	0.04
	RT 1646B			6 V or 1 P 9 V	0.12 (6V or 1P) 0.18 (9V)	P: 50 usec; 45/1 V: 18 usec; 9.6/12	0.2 (6V or 1P) 0.3 (9V)
Canadian Marconi Company, Radio Relay Dept., 970 McEachran Ave., Montreal.	DQ 48B	750–1,000	PM	132 V	2.5	1.5 usec; 50/ns	2.2
	DQ 58B	1,700–2,400	FM	240 V	4.3	200/100	4.3
	DQ 58C	1,700–2,400	FM	600 V or 1TV	14 18	See note 16	14 18
Cdn. Westinghouse Co. Ltd., Box 510, Hamilton, Ont.	HJ–LV	4,400–5,000	FM	120 V	1.8	0.58 usec; 140/ns	1.8
Collins Radio Co., Dallas, Tex.*	MW–502, MW–103	5,925–8,500	FM	240 V (alt. 600 V or 1 TV)	12	6db/0, 552–1052kc; 240/60	6.4
E.M.I. Electronics Ltd., Hayes, England (E.M.I.-Cossor Electronics Ltd., 2005 MacKay St., Montreal)	FL4A	6,875–7,125 7,050–7,300	FM	1 TV	22	2500/0.05	18
	FL6A	4,400–4,800					
G.E.C. (Electronic Equipment and Tube Dept., Cdn. General Electric Co. Ltd., 830 Landsdowne Ave., Toronto 4.)	SPO 5502	1,700–2,300	FM	300 V or 1 TV	5.4 20	200/ns 5600/ns	5.4
	SPO 5555	5,925–6,425	FM	960 V or 1 TV	18 20	200/ns 5500/ns	18
Lenkurt Electric Co. of Canada Ltd., 7018 Lougheed Hwy., Vancouver, B.C. (Automatic Electric Sales (Canada) Ltd. 185 Bartley Dr., Toronto 16.)	72C–900	860–960	FM	120 V	2	2.6 usec; 32/12	1.03
	74A2 Microtel	5,925–8,500	FM	264 V	4	0.5 usec; 100/40	2.4
Motorola, Inc., Chicago, Ill. (Canadian Motorola Electronics Ltd., 105 Bartley Dr., Toronto 16.)	Y35 AAB	890–960	FM	8 V	0.2	40/ns	0.2
	MV–10	5,925–6,425 6,875–7,125	FM	1 TV+1 P	30	3db/0, 0.5-3.5mc; Deviation n/s	15
	MR–20	5,925–7,650	FM	360 V or more	22 max.	5000/ns	10
	Wide-band Relay	7,125–8,000	FM	300 V	30 max.	5000/ns	11–15
Northern Electric Co. Ltd., Box 6124, Montreal. [redacted]	TD–2	3,700–4,200	FM	1 TV or 600 V	20	2800/ns	12
	TJ	10,700–11,700	FM	1 TV or 600 V	20	4000/ns	20
	J–1170	450–470	FM	24 V 48 V	1	3 usec 250/250	0.8 1
	R 20003 Tx R 20002 Rx	755–980	FM	180 V	8	1.7 usec 2000/800	5.8

General notes

n/a—Not applicable.

n/s—Not specified. In some cases this means that the information was given by the manufacturer, but in a form that could not validly be compared with that for other equipments.

HF—Traffic.

Sup—Supervisory.

1. Where space permits, names and addresses of C dian representatives are given in parentheses. C representatives (for entries marked *) are:

Collins Radio Co.—Collins Radio Co. of Canada 11 Bermondsey Rd., Toronto 16.

Siemens & Halske—The Ahearn and Soper Co. 384 Bank St., Ottawa 4.

Westinghouse Electric Corp.—Canadian Westingl Co. Ltd., Box 510, Hamilton.

Microwave Relay Equi

Transmitted Power Output (6)	Baseband Frequency Range (kc)	Frequency Stability (%)		Modulation Input (dbm) (7)		Baseband Output Level (dbm)		Baseband Input & Output Z (ohms) (8)	Baseband Fr Respons
		Tx	Rx	HF	Sup.	HF	Sup.		HF
16 watts	HF: 0.3–3.4	0.001	0.001	—18	n/a	+8.5	n/a	HF: 600	±3 db 0.3–3.4
	HF: 3.4–36(6V) 3.4–54(9V) 0.05–15(1P) Sup: 0.3–3.4(6–9V)			—30	—30	0	0	HF: 150/600 Sup: 150/600	±1.5 db, 0.
5 watts or 20 watts	HF: 12–552 Sup: 0.3–3	0.005	0.005	—34	—36/—30	—9	—10/—16	HF: 75 Sup: 600	±1 db 12–552
10 watts	HF: 12–1052 Sup: 0.3–10	0.01	0.005	—45	—20	—15	+4	HF:75 Sup: 600	±0.5 db 60–1052
10 watts	HF: 60–3000 0–5000	0.01	0.005	—45 0.25v dap	n/a	—20 1.4v dap	n/a	HF: 75	±0.5 db 60–3000 (600V) 0–5000 (1 TV)
250 mw or 2.5 watts	HF: 12–600 Sup: 0.3–10	0.5 to 0.001	AFC	—52	—37	—15	—8	HF: 75U Sup: 600U	±1 db 12–552
100 mw	HF: 60–1052 Sup: 0.4–11 or 40–50	0.05 (AFC opt.)	AFC	—13.5	0/—10	—13.5	0	HF: 135 Sup: 600	n/s
2 watts 4 watts	HF: 0–7000	0.05	0.05	1v	n/a	1v	n/a	HF: 75	±1 db 0–6000
4 watts	HF: 60–1500 0–5000 Sup: 0.3–10	0.01	0.01	—45 .05 to 1v p–p	—30	—15 1 to 1.4v p–p	0	HF: 75U Sup: 600	Subst. flat 60–1400 (V) 0–5000 (TV)
5 watts	HF: 60–4200 0–6000 Sup: 0.3–10	0.01	0.01	—45 1v p–p	—30	—20 1v p–p	0	HF: 75U Sup: 600	Subst. flat 60–4028(V) 0–6000 (TV)
5 watts	HF: 12–552 Sup: 0.3–12	0.005	0.005	—35	—20	—5	0	HF: 130 Sup: 600	±1 db 12–552
800 mw	HF: 12–1300 Sup: 0.3–8	AFC	AFC	—10/—40	0/—28	—15	—4	HF: 75U Sup: 600	±0.25 db 12–1300
5 watts	HF: 0.3–32 Sup: 0.3–3	0.0005	AFC	—15	—15	+10	1 watt in 3 ohms	HF: 600 Sup: 600	±2 db 0.3–32
100 mw	HF: 0.03–6500	0.05	AFC	0.25v p–p	n/a	1.4v p–p	n/a	HF: 75/124	+1–2 db 0.03–6500
100 mw	HF: 0.3–3000	0.05	AFC	—8	—36	—8	n/s	HF: 75 Sup: Bridged	±1 db 0.3–3000
100 mw	HF: 0.008–6000	0.03	AFC	0.2v p–p	—18	0.25v	n/s	HF: 72	±0.5–3db 0.008–6000
500 mw	HF: 0.03–7000 Sup: Separate equipment	0.001	0.001	0.25v p–p	n/a	1.6v p–p	n/a	HF: 124 or 75U	±0.1 db 0.03–7000
500 mw	HF: 3–6000 Sup: 0.06–3	0.05	AFC	—24	—10	0	0	HF: 124 or 75U Sup: 600	±0.2 db 0.06–6000
10 watts	HF: 12–250 Sup: 0.3–12	0.0005	0.001	—15	—20	—10	—10	HF: 135 Sup: 600	± 3 db 12–250 (48V)
5 watts	HF: 12–800 Sup: 0.5–12	0.003	0.003	—20	—20	—10	—10	HF: 75U Sup: 600	±1 db 12–800

f Cana-
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da Ltd.,

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nghouse

2. PM—Phase modulation; FM—Frequency modulation.
3. P—Program; TV—Television; V—Voice.
4. Column A gives pre-emphasis (if used), either as a time constant or in db/O over a specified frequency range; and deviation at a specified modulating frequency, for example, 12/1 indicates ± 12kc deviation at f = 1kc. Where deviation is given thus: 50/ns, modulating frequency was not specified; deviation is assumed to be maximum.
5. Column B gives bandwidth in megacycles occupied by 99% of the radiated energy for white noise loading of the baseband corresponding to traffic not exceeding 1% of the busy hour for the applicable channel capacity.
6. At antenna feeder input.
7. HF modulation input normally given in dbm per channel, supervisory modulation input at channel test tone level, both for 100% deviation.

Microwave Relay Equi

Transmitted Power Output (6)	Baseband Frequency Range (kc)	Frequency Stability (%)		Modulation Input (dbm) (7)		Baseband Output Level (dbm)		Baseband Input & Output Z (ohms) (8)	Baseband Fr Respons
		Tx	Rx	HF	Sup.	HF	Sup.		HF
16 watts	HF: 0.3–3.4	0.001	0.001	—18	n/a	+8.5	n/a	HF: 600	±3 db 0.3–3.4
	HF: 3.4–36(6V) 3.4–54(9V 0.05–15(1P) Sup: 0.3–3.4(6–9V)			—30	—30	0	0	HF: 150/600 Sup: 150/600	±1.5 db, 0.
5 watts or 20 watts	HF: 12–552 Sup: 0.3–3	0.005	0.005	—34	—36/—30	—9	—10/—16	HF: 75 Sup: 600	±1 db 12–552
10 watts	HF: 12–1052 Sup: 0.3–10	0.01	0.005	—45	—20	—15	+4	HF:75 Sup: 600	±0.5 db 60–1052
10 watts	HF: 60–3000 0–5000	0.01	0.005	—45 0.25v dap	n/a	—20 1.4v dap	n/a	HF: 75	±0.5 db 60–3000 (600V) 0–5000 (1 TV)
250 mw or 2.5 watts	HF: 12–600 Sup: 0.3–10	0.5 to 0.001	AFC	—52	—37	—15	—8	HF: 75U Sup: 600U	±1 db 12–552
100 mw	HF: 60–1052 Sup: 0.4–11 or 40–50	0.05 (AFC opt.)	AFC	—13.5	0/—10	—13.5	0	HF: 135 Sup: 600	n/s
2 watts 4 watts	HF: 0–7000	0.05	0.05	1v	n/a	1v	n/a	HF: 75	±1 db 0–6000
4 watts	HF: 60–1500 0–5000 Sup: 0.3–10	0.01	0.01	—45 .05 to 1v p–p	—30	—15 1 to 1.4v p–p	0	HF: 75U Sup: 600	Subst. flat 60–1400 (V) 0–5000 (TV)
5 watts	HF: 60–4200 0–6000 Sup: 0.3–10	0.01	0.01	—45 1v p–p	—30	—20 1v p–p	0	HF: 75U Sup: 600	Subst. flat 60–4028(V) 0–6000 (TV)
5 watts	HF: 12–552 Sup: 0.3–12	0.005	0.005	—35	—20	—5	0	HF: 130 Sup: 600	±1 db 12–552
800 mw	HF: 12–1300 Sup: 0.3–8	AFC	AFC	—10/—40	0/—28	—15	—4	HF: 75U Sup: 600	±0.25 db 12–1300
5 watts	HF: 0.3–32 Sup: 0.3–3	0.0005	AFC	—15	—15	+10	1 watt in 3 ohms	HF: 600 Sup: 600	±2 db 0.3–32
100 mw	HF: 0.03–6500	0.05	AFC	0.25v p–p	n/a	1.4v p–p	n/a	HF: 75/124	+1–2 db 0.03–6500
100 mw	HF: 0.3–3000	0.05	AFC	—8	—36	—8	n/s	HF: 75 Sup: Bridged	±1 db 0.3–3000
100 mw	HF: 0.008–6000	0.03	AFC	0.2v p–p	—18	0.25v	n/s	HF: 72	±0.5–3db 0.008–6000
500 mw	HF: 0.03–7000 Sup: Separate equipment	0.001	0.001	0.25v p–p	n/a	1.6v p–p	n/a	HF: 124 or 75U	±0.1 db 0.03–7000
500 mw	HF: 3–6000 Sup: 0.06–3	0.05	AFC	—24	—10	0	0	HF: 124 or 75U Sup: 600	±0.2 db 0.06–6000
10 watts	HF: 12–250 Sup: 0.3–12	0.0005	0.001	—15	—20	—10	—10	HF: 135 Sup: 600	± 3 db 12–250 (48V)
5 watts	HF: 12–800 Sup: 0.5–12	0.003	0.003	—20	—20	—10	—10	HF: 75U Sup: 600	±1 db 12–800

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2. PM—Phase modulation; FM—Frequency modulation.
3. P—Program; TV—Television; V—Voice.
4. Column A gives pre-emphasis (if used), either as a time constant or in db/O over a specified frequency range; and deviation at a specified modulating frequency, for example, 12/1 indicates ± 12kc deviation at f = 1kc. Where deviation is given thus: 50/ns, modulating frequency was not specified; deviation is assumed to be maximum.
5. Column B gives bandwidth in megacycles occupied by 99% of the radiated energy for white noise loading of the baseband corresponding to traffic not exceeding 1% of the busy hour for the applicable channel capacity.
6. At antenna feeder input.
7. HF modulation input normally given in dbm per channel, supervisory modulation input at channel test tone level, both for 100% deviation.

ipment Specifications

Copyright Dec

requency e (kc) / Sup.	Receiver Noise Figure (db) (9)	Receiver Sensitivity (dbm) (10)	Idle Noise (11)	I/M Noise (12)	No. of RF Channels on One Antenna	Type of Repeater (13)	Standby Facilities Available (14)	Switching Time to Standby	Multi-RF Channel Proection
n/a	11	—113	20 dba	n/a	1	B	D, HS, CS	D: 0 HS: 0.3 sec CS: 40 sec	No
05—54		—92(V) —105(P)	20 dba	25 dba rms					
±2 db 0.4–11	12	—84	18 dba	26 dba	2	B	D, HS, CS	D: 5 ms HS: 20 sec CS: n/s	No
±1 db 4–10	13	—80	12 dba	16 dba*	6	H	HS, TP	HS: 3 sec TP: 50 ms	n/s
n/a	13	—80	12 dba	12 dba*	6	H	HS	20 ms	5 for 1
±1–3db 0.3–10	10	—86	14.5 dba	14.5 dba	1	B	D, HS	D: 0 HS: 0.5 sec	No
n/s	14	—77	13 dba	n/s	Up to 18	B	D, HS	D: 2.5 ms HS: 25 ms	No
n/a	14 17	—40	n/s	n/a	2	B	HS	50 ms	No
Subst. flat 0.3–10	10	—83	9 dbao	12 dbao	6	H	D	1 usec	2 for 1 5 for 1
Subst. flat 0.3–10	10	—75	9 dba	14 dbao	6	H	D, HS	D: 1 usec HS: 150 ms	2 for 1 5 for 1
±3 db 0.3–12	12	—78	17 dbao	23 dbao	3 two-way	B	D, HS	D: 0 HS: 5secs	No
±0.5 db 0.3–8	13	—82	12 dbao	9 dbao	4 two-way	B	D, HS	D: 0 HS: 700 usec	2 for 1 3 for 1
±3 db 0.3–3	14	—95	15 dba	20 dba	4	B	D, HS, CS	HS: 55 ms D and CS n/s	No
n/a	15	n/s	n/s	n/s	5 or more	B	HS	55 ms	No
±2 db 0.3–3	15	—76	13 dba	15 dba	5 or more	B	D, HS, CS	D: 0 HS: 55 ms CS: 45 sec	2 for 1
n/a	14	—80	20 dba	25 dba	6	B	D, HS, CS	D: 0 HS: 50 ms CS: 30 sec	Yes
n/a	12	—77	12 dba	15 dba	7 or 12 (Alt. 6–TJ and 8–TH)	H, B	D, HS	D: 1 to 25ms HS: n/s	5 for 1
±0.2 db 0.06–3	15	—76	10 dba	13 dba	6 two-way	B	D	1.4 ms	Yes
±3 db 0.3–12	8	—92 (24V)	17 dba	19 dba (24V)	2 two-way	B	D, TP	D: 0 TP: n/s	No
±3 db 0.5–12	8	—87	17 dba	19 dba	1 two-way	B	D, TP	D: 0 TP: n/s	No

8. U—Unbalanced.
9. Measured through receiver pre-selection filter.
10. Minimum receiver input signal for 52dba per-channel noise, measured in worst channel.
11. Idle noise normally given in dba for a single terminal, uncombined, and not governed by level of rf received signal. Values specified in dbao are referred to the zero transmission level point; values in dba were not so specified, but are assumed to refer to 0TLP.
12. Intermodulation noise normally given in dba for rated channel capacity, measured with F1A weighting in 3-kc band, single terminal, uncombined, with system noise loading equivalent to that not exceeded by more than 1% of the busy-hour traffic (mean for entries marked*). Values specified in dbao are referred to 0TLP; values in dba were not so specified, but are assumed to refer to 0TLP.
13. B—Back-to-back terminal; H—Heterodyne.

ipment Specifications

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requency e (kc) / Sup.	Receiver Noise Figure (db) (9)	Receiver Sensitivity (dbm) (10)	Idle Noise (11)	I/M Noise (12)	No. of RF Channels on One Antenna	Type of Repeater (13)	Standby Facilities Available (14)	Switching Time to Standby	Multi-RF Channel Proection
n/a	11	—113	20 dba	n/a	1	B	D, HS, CS	D: 0 HS: 0.3 sec CS: 40 sec	No
05—54		—92(V) —105(P)	20 dba	25 dba rms					
±2 db 0.4–11	12	—84	18 dba	26 dba	2	B	D, HS, CS	D: 5 ms HS: 20 sec CS: n/s	No
±1 db 4–10	13	—80	12 dba	16 dba*	6	H	HS, TP	HS: 3 sec TP: 50 ms	n/s
n/a	13	—80	12 dba	12 dba*	6	H	HS	20 ms	5 for 1
±1–3db 0.3–10	10	—86	14.5 dba	14.5 dba	1	B	D, HS	D: 0 HS: 0.5 sec	No
n/s	14	—77	13 dba	n/s	Up to 18	B	D, HS	D: 2.5 ms HS: 25 ms	No
n/a	14 17	—40	n/s	n/a	2	B	HS	50 ms	No
Subst. flat 0.3–10	10	—83	9 dbao	12 dbao	6	H	D	1 usec	2 for 1 5 for 1
Subst. flat 0.3–10	10	—75	9 dba	14 dbao	6	H	D, HS	D: 1 usec HS: 150 ms	2 for 1 5 for 1
±3 db 0.3–12	12	—78	17 dbao	23 dbao	3 two-way	B	D, HS	D: 0 HS: 5secs	No
±0.5 db 0.3–8	13	—82	12 dbao	9 dbao	4 two-way	B	D, HS	D: 0 HS: 700 usec	2 for 1 3 for 1
±3 db 0.3–3	14	—95	15 dba	20 dba	4	B	D, HS, CS	HS: 55 ms D and CS n/s	No
n/a	15	n/s	n/s	n/s	5 or more	B	HS	55 ms	No
±2 db 0.3–3	15	—76	13 dba	15 dba	5 or more	B	D, HS, CS	D: 0 HS: 55 ms CS: 45 sec	2 for 1
n/a	14	—80	20 dba	25 dba	6	B	D, HS, CS	D: 0 HS: 50 ms CS: 30 sec	Yes
n/a	12	—77	12 dba	15 dba	7 or 12 (Alt. 6–TJ and 8–TH)	H, B	D, HS	D: 1 to 25ms HS: n/s	5 for 1
±0.2 db 0.06–3	15	—76	10 dba	13 dba	6 two-way	B	D	1.4 ms	Yes
±3 db 0.3–12	8	—92 (24V)	17 dba	19 dba (24V)	2 two-way	B	D, TP	D: 0 TP: n/s	No
±3 db 0.5–12	8	—87	17 dba	19 dba	1 two-way	B	D, TP	D: 0 TP: n/s	No

8. U—Unbalanced.
9. Measured through receiver pre-selection filter.
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12. Intermodulation noise normally given in dba for rated channel capacity, measured with F1A weighting in 3-kc band, single terminal, uncombined, with system noise loading equivalent to that not exceeded by more than 1% of the busy-hour traffic (mean for entries marked*). Values specified in dbao are referred to 0TLP; values in dba were not so specified, but are assumed to refer to 0TLP.
13. B—Back-to-back terminal; H—Heterodyne.
14. I
15. I

Ambient Temp. Range (°F)	Ambient Humidity Range (%)	Built-in Metering Facilities	Blowers or Fans Used	Alarms Available	Space Occupied (15)	Power Supply Options and Requirements
—22/+120	0/95	Plug-in	Yes	Tx–3 Rx–2	A: 25×16×10 in B: 2×A+20×16×7 in C: 2×A D: 4×A+27×16×7 in	110–125/220–250 vac A: 230 w C: 460 w B: 550 w D: 1.1 kw
+32/+110	0/95 (Short periods)	Plug-in	Yes	Tx–1 Rx–1	A: 6 ft C: 12 ft. B: 12 ft. D: 24 ft.	115 vac A: 400 va C: 800 va B: 800 va D: n/s
+32/+122	0/95	Yes	Yes	Tx–2 Rx–2	A: 92×32×18 in. B and C: 2×A D: 4×A	100–130 vac A: 1.42 kva C: 2.84 kva B: 3 kva D: 6 kva
+32/+122	0/95	Yes	Yes	Tx–1 Rx–2	A: 80×32×16 in. B and C: 2×A D: 4×A	100–130 vac A: 1 kva C: 2.2 kva B: 2.2 kva D: 4.2 kva
+32/+122	0/95	Yes	No	Tx–3 Rx–3	A: 52 RU C: 99 RU B: 84RU D: 163 RU	115/230 vac A: 570 va C: 1.1 kva B: 1.1 kva D: 2.1 kva
—22/+140	0/95	Yes	No	Tx–2 Rx–4	A: 8 ft. C: 16 ft. B: 16 ft. D: 24 ft.	115 vac; 130/24 vdc; 130/48 vdc; 24 vdc; 48 vdc Requirements n/s
0/+120	0/95	Yes	Yes	Tx–2 Rx–1	A: 6 ft. C: 12 ft. B: 13 ft. D: 26 ft.	115/230 vac A: 500 va C: 1 kva B: 1 kva D: 2 kva
+32/+122	0/95	Yes	No	n/s	A and C: 90×20½×17 in. B: 90×41×17 in. D: 90×85½×17 in.	95–125/180–250 vac A: 510 va C: 820 va B: 1.29 kva D: 1.76 kva
+32/+122	0/95	Yes	Yes	n/s	A and C: 90×41×17 in. B and D: 90×61½×17 in.	95–125/180–250 vac A: 820 va C: 1 kva B: 1.42 kva D: 2 kva
+32/+122	0/95	Yes	Yes	Tx–2 Rx–2	A: 70 RU C: 144 RU B: 144 RU D: 288 RU	115 vac A: 435 w C: 900 w B: 1 kw D: 2 kw
+32/+122	0/95	Yes	No	Tx–3 Rx–2	A: 26 RU C: 62 RU B: 59 RU D: 124 RU	115 vac; 130/24 vdc; 130/48 vdc; 24 vdc; 48 vdc See note 17
—22/+140	0/95	Yes	Yes	Tx–1 Rx–1	A: 52 in. C: 104 in. B: 115 in. D: 229 in.	117 vac Requirements n/s
—20/+130	0/95	Yes	No	Tx–1 Rx–1	A: 64 in. C: 168 in. B: 168 in. D: 336 in.	117 vac A: 450 w B, C, D: n/s
—20/+130	0/95	Yes	No	n/s	A: 47½ in. C: 95 in. B: 99¾ in. D: 200 in.	117 vac A: 540 w C: 1.08 kw B: 1.18 kw D: 2.36 kw
MIL–E–4158		Yes	No	n/s	A: 14 ft. C: 28 ft. B: 14 ft. D: 28 ft.	117 vac Requirements n/s
0/+110	0/95	Yes	Yes	5 per bay	A: 13.5 ft. C: 18 ft. B: 27 ft. D: 36 ft.	n/s
0/+120	0/95	Yes	Yes	2 per bay	A: 6 ft. C: 12 ft. B: 12 ft. D: 24 ft.	110 vac A: 375 w C: 750 w B: 800 w D: 1.6 kw
+32/+110	0/95	Yes	Yes	Tx–2 Rx–2	A: 30 in. C: 60 in. B: 62 in. D: 144 in.	110 vac A: 600 w C: 1.2 kw B: 1.2 kw D: 2.4 kw
+32/+110..	0/95	Yes	Yes	Tx-3 Rx–3	A: 14 ft. C: 28 ft. B: 28 ft. D: 56 ft. B: 28 ft. D: 56 ft.	110 vac A: 800 w C: 1.6 kw B: 1.6 kw D: 3.2 kw

D—Diversity; HS—Hot standby; CS—Cold standby; TP—Twin-path (parallel operation on single frequency).

Linear height of mounting in inches, feet or standard 1¾-in. rack units (RU). Some equipments are suitable for back-to-back mounting. Dimensions given thus: 25x16x10 in., indicate cabinet type mounting.
A—Single terminal; B—Terminal with standby; C—Single repeater; D—Repeater with standby.

Specific notes

16. Deviation for Cdn. Marconi DQ58C is: 200kc rms per channel plus CCIR 600-channel pre-emphasis, or 8mc dap plus CCIR 575-line pre-emphasis.

17. Lenkurt 74A2 Microtel power requirements are: A: 280w; B: 560w; C: 560w; D: 1.12kw.

(Table continued on reverse side)

Microwave Relay Equipment Specifications—Continued

Manufacturer's Name and Address (See note 1)	Model No. and/or Name	Frequency Range (mc)	Type of Modulation (2)	Channel Capability and Type (3)	Transmitted RF Bandwidth (mc)	Peak Frequency Deviation		Transm Pow Outp (6
						A (4)	B (5)	
RCA Victor Co. Ltd., 1050 Lacasse St., Montreal 30.	CW-20A	1,700–1,990	FM	30 V	6	80/ns	1.7	3 watt
	CW-20AW	1,700–1,990	FM	120 V	6	80/ns	1.7	3 watt
	CW-20/240	1,700–2,300	FM	240 V	7.5	150/ns	3.5	5 watt
	CTR-250	235–300	FM	72V	2.8	50/ns	1.0	50 wa
	CTR-900	890–960	FM	24 V	0.65	14/ns	0.31	500 m
Siemens & Halske, Munich, Germany*	FM 7000	6,325–8,500	FM	120 V	4.5	6db/0, 6-552kc; 100/ns	n/s	1 watt
Standard Telephones & Cables Ltd., London, England (Standard Telephones & Cables Mfg. Co. (Canada) Ltd., 9600 St. Lawrence Blvd., Montreal.)	GF-1	1,700–2,300	FM	120 V	n/s	n/s	n/s	5 watt
	RL-4	3,600–4,200	FM	1 TV or 960 V	n/s	n/s	n/s	5 watt
	7400 mc FM Radio System	7,300–7,500	FM	1 TV or 240 V	n/s	n/s	n/s	800 m
	7000 mc Portable OB Equipment	7,050–7,300	FM	1 TV+1 P	n/s	8000/ns	n/s	850 m
Westinghouse Electric Corp., East Pittsburgh, Pa.*	FR-1	1,700–1,990 2,110–2,300	FM	120 V	4	2000/ns	n/s	2 watt

Reliability

Continued from page 42

commercial case, but some of the assessment techniques used by the military can be of help in the selection of the best available equipment for a given application.

Survival probability is inversely related to equipment complexity; the simplest way of achieving a given performance level is usually the most reliable. This is not to say that corners should be cut or marginal circuitry used, but investigation has shown that the mean time to failure (the reciprocal of survival probability) is dependent upon the number of components involved in the equipment. One of the formulas used in specifications for military electronic equipment in the United States, although not completely applicable in the commercial case, serves to indicate the general principle and the types of component considered most sensitive to failure[1]:

$$\text{Mean-time-between-failures} = 1/F_r \text{ (Failure rate)}$$

Where:

$$F_r = 30 \times 10^{-6} \times N_t + 15 \times 10^{-6} \times N_m + 2 \times 10^{-6} \times N_s + 0.5 \times 10^{-6} \times N_c$$

N_t = Total number of vacuum tubes employed in equipment

N_m = Total number of motors and relays

N_s = Total number of semiconductor devices

N_c = Total number of remaining electrical and electromechanical parts

This formula reflects findings based on the components which were available during the investigation, and the individual factors for each type of component are subject to change as the components become more reliable. Semiconductor reliability, for example, is being improved on a day-to-day basis. Further, the statistics are based on the use of JAN components, and thus have a certain qualitative, as well as quantitative, meaning. The approach can however, be used as a guide to equipment assessment when it is applied in conjunction with an investigation of component rating, electrical and mechanical construction, cooling methods, etc. In the commercial field, the manufacturer's reputation for quality control must substitute for JAN and MIL specifications as far as individual component quality is concerned.

Performance reliability

The provision and maintenance of a given grade of service — the "intended function" of the system — is often called "performance reliability." This is normally expressed in terms of the percentage of time during which the signal-to-noise ratio measured in the channels will not be worse than some specified value. Obviously, any performance reliability figure should take into account the failure rate associated with the survival probability of the equipment itself, although the converse does not hold. It should be possible to assess the relative merits of a given system on the basis of its performance reliability, since this parameter is a measure of system engineering, the propagation characteristics of the paths chosen, the ability of the system to provide the required performance under adverse transmission conditions, and the inherent survival probability of the equipment.

If a prospective user of microwave equipment purchases a complete system on a pre-engineered basis, a guarantee of system performance can be provided by the equipment manufacturer, and competitive equipments may be assessed on an over-all system basis. If, on the other hand, the equipment purchaser does his own engineering, the performance characteristics of the equipment itself be-

nsmitted Power Output (6)	Baseband Frequency Range (kc)	Frequency Stability (%)		Modulation Input (dbm) (7)		Baseband Output Level (dbm)		Baseband Input & Output Z (ohms) (8)	Baseba Res
		Tx	Rx	HF	Sup.	HF	Sup.		HF
watts	0.03–160	0.02	n/s	n/s	n/s	—10	n/s	HF: 600	n/s
watts	0.03–160	0.02	n/s	n/s	n/s	—16	n/s	HF: 135U	n/s
watts	0.03–2100	0.02	n/s	n/s	n/s	—15	n/s	HF: 75U	n/s
watts	n/s	0.005	n/s	n/s	n/s	n/s	n/s	HF: 150	n/s
mw	0.03–140	0.005	n/s	n/s	n/s	—13	n/s	HF: 600	n/s
watt	HF: 6–552 Sup: 0.3–3.4	0.02	n/s	n/s	n/s	n/s	n/s	HF: 150 or 75U Sup: 600	±0.3 db 6–552
watts	n/s	0.0015	0.0015	—40/—52	n/s	—11/—23	n/s	HF: 75 Sup: n/s	n/s
watts	HF: 0.002–5000 Sup: Separate equipment	0.005	0.005	TV: 1v dap	n/a	TV: 0.7–1.4v dap	n/a	HF: 75	±0.5 dl 0.015–5000
mw	n/s	n/s	n/s	n/s	n/s	—30	n/s	n/s	n/s
mw	HF: 15–7000 Sup: 0.03–15	0.02	0.02	1v	n/a	1v	n/a	HF: 75	Subst. flat 0.015–500
watts	HF: 4–600 Sup: 0.3–4	0.05 total for system; 0.02 for one station		—17	—19	—23	—25	HF: 135 Sup: 135	±1 to 2db 4–600

come even more important, since no system performance guarantee can be associated with the purchase of equipment on a merchandise basis. Strictly speaking, the microwave equipment itself should be carefully examined even when an over-all-engineered system is purchased, since, in the final analysis, a guarantee is only as good as the equipment; the enforcement of guarantee clauses over a protracted period of time is often impracticable from the user point of view, and valuable revenue can be lost in the interim.

The degradation of signal-to-noise ratio in a microwave system is due to a change in one or both of two types of noise: thermal, or idle, noise; and nonlinear noise or intermodulation. Thermal noise is affected by propagation conditions as well as equipment characteristics. Intermodulation noise depends upon system loading and is generally specified in terms of an activity factor for the channels. The anticipated depth of fades and the percentage of time over which they will occur can be calculated theoretically, and the expected peak loading on the system is also subject to theoretical treatment, so that both types of noise are governed by statistical objectives. As mentioned later, the two types of noise are inter-related.

There are several sources of noise in an over-all system, of course, but the noise contributed by the radio equipment itself is of principal concern here. Other equipment characteristics, such as transmitter power output, are also of importance, since they affect the tolerable transmission-medium noise and therefore the makeup of the system in which the equipment is to be used.

Thermal noise is contributed by both the transmitter and receiver. Transmitter noise is generally a result of random current fluctuations in the modulator and final stages; in the case of transmitters using klystrons, of "klystron jitter." Transmitter noise actually determines the minimum thermal noise level in the system, since it is present when the receiver is at saturation. Although it is not directly related to modulation level, its effect can be reduced by increasing this level to improve the ratio between transmitter noise and transmitted intelligence. Since raising the modulation level also raises the intermodulation noise, a compromise must be reached.

Receiver noise

Probably the most significant parameter relating to system performance reliability is receiver noise, which determines the "sensitivity" of the receiver. It is a characteristic of FM receivers (and FM, or effective FM, is almost universally used in microwave systems) that the noise in the channels is linearly related to received signal strength, between the extremes of transmitter noise, which is the minimum level, and the receiver noise threshold, at which point the noise masks the signal completely. The noise in the channels increases db-for-db as signal strength decreases during fading, and the lower the receiver noise threshold the longer the channels will remain within acceptable noise limits.

The receiver noise threshold is determined by the equivalent noise input to the receiver plus the noise generated within the receiver itself. The noise input portion of this total is a function of receiver bandwidth, and the noise threshold can therefore be lowered by reducing the receiver bandwidth. A receiver with one-half the bandwidth of another will exhibit a 3 db noise threshold advantage, and will therefore tolerate a 3 db deeper fade for the same channel noise level. Once again, however, minimizing the thermal noise can result in an increase in intermodulation noise, and a compromise is necessary. The receiver bandwidth should be just wide enough to accept the necessary intelligence with a minimum of intermodulation.

smitted wer tput (6)	Baseband Frequency Range (kc)	Frequency Stability (%)		Modulation Input (dbm) (7)		Baseband Output Level (dbm)		Baseband Input & Output Z (ohms) (8)	Baseband Frequ Response (k
		Tx	Rx	HF	Sup.	HF	Sup.		HF
atts	0.03–160	0.02	n/s	n/s	n/s	—10	n/s	HF: 600	n/s
atts	0.03–160	0.02	n/s	n/s	n/s	—16	n/s	HF: 135U	n/s
atts	0.03–2100	0.02	n/s	n/s	n/s	—15	n/s	HF: 75U	n/s
watts	n/s	0.005	n/s	n/s	n/s	n/s	n/s	HF: 150	n/s
mw	0.03–140	0.005	n/s	n/s	n/s	—13	n/s	HF: 600	n/s
att	HF: 6–552 Sup: 0.3–3.4	0.02	n/s	n/s	n/s	n/s	n/s	HF: 150 or 75U Sup: 600	±0.3 db 6–552
atts	n/s	0.0015	0.0015	—40/—52	n/s	—11/—23	n/s	HF: 75 Sup: n/s	n/s
atts	HF: 0.002–5000 Sup: Separate equipment	0.005	0.005	TV: 1v dap	n/a	TV: 0.7–1.4v dap	n/a	HF: 75	±0.5 dB 0.015–5000
mw	n/s	n/s	n/s	n/s	n/s	—30	n/s	n/s	n/s
mw	HF: 15–7000 Sup: 0.03–15	0.02	0.02	1v	n/a	1v	n/a	HF: 75	Subst. flat 0.015–5000
atts	HF: 4–600 Sup: 0.3–4	0.05 total for system; 0.02 for one station		—17	—19	—23	—25	HF: 135 Sup: 135	±1 to 2db 4–600

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come even more important, since no system performance guarantee can be associated with the purchase of equipment on a merchandise basis. Strictly speaking, the microwave equipment itself should be carefully examined even when an over-all-engineered system is purchased, since, in the final analysis, a guarantee is only as good as the equipment; the enforcement of guarantee clauses over a protracted period of time is often impracticable from the user point of view, and valuable revenue can be lost in the interim.

The degradation of signal-to-noise ratio in a microwave system is due to a change in one or both of two types of noise: thermal, or idle, noise; and nonlinear noise or intermodulation. Thermal noise is affected by propagation conditions as well as equipment characteristics. Intermodulation noise depends upon system loading and is generally specified in terms of an activity factor for the channels. The anticipated depth of fades and the percentage of time over which they will occur can be calculated theoretically, and the expected peak loading on the system is also subject to theoretical treatment, so that both types of noise are governed by statistical objectives. As mentioned later, the two types of noise are inter-related.

There are several sources of noise in an over-all system, of course, but the noise contributed by the radio equipment itself is of principal concern here. Other equipment characteristics, such as transmitter power output, are also of importance, since they affect the tolerable transmission-medium noise and therefore the makeup of the system in which the equipment is to be used.

Thermal noise is contributed by both the transmitter and receiver. Transmitter noise is generally a result of random current fluctuations in the modulator and final stages; in the case of transmitters using klystrons, of "klystron jitter." Transmitter noise actually determines the minimum thermal noise level in the system, since it is present when the receiver is at saturation. Although it is not directly related to modulation level, its effect can be reduced by increasing this level to improve the ratio between transmitter noise and transmitted intelligence. Since raising the modulation level also raises the intermodulation noise, a compromise must be reached.

Receiver noise

Probably the most significant parameter relating to system performance reliability is receiver noise, which determines the "sensitivity" of the receiver. It is a characteristic of FM receivers (and FM, or effective FM, is almost universally used in microwave systems) that the noise in the channels is linearly related to received signal strength, between the extremes of transmitter noise, which is the minimum level, and the receiver noise threshold, at which point the noise masks the signal completely. The noise in the channels increases db-for-db as signal strength decreases during fading, and the lower the receiver noise threshold the longer the channels will remain within acceptable noise limits.

The receiver noise threshold is determined by the equivalent noise input to the receiver plus the noise generated within the receiver itself. The noise input portion of this total is a function of receiver bandwidth, and the noise threshold can therefore be lowered by reducing the receiver bandwidth. A receiver with one-half the bandwidth of another will exhibit a 3 db noise threshold advantage, and will therefore tolerate a 3 db deeper fade for the same channel noise level. Once again, however, minimizing the thermal noise can result in an increase in intermodulation noise, and a compromise is necessary. The receiver bandwidth should be just wide enough to accept the necessary intelligence with a minimum of intermodulation.

Frequency se (kc) Sup.	Receiver Noise Figure (db) (9)	Receiver Sensitivity (dbm) (10)	Idle Noise (11)	I/M Noise (12)	No. of RF Channels on One Antenna	Type of Repeater (13)	Standby Facilities Available (14)	Switching Time to Standby	Multi-RF Channel Proection
n/s	12	n/s	n/s	n/s	n/s	H	CS	n/s	n/s
n/s	10	n/s	n/s	n/s	n/s	H	D, CS	n/s	n/s
n/s	9	n/s	n/s	n/s	n/s	H	D	n/s	n/s
n/s	9	n/s	n/s	n/s	n/s	H	HS, CS	n/s	n/s
n/s	12	n/s	n/s	n/s	n/s	H	HS, CS	n/s	n/s
±0.3 db 0.3–3.4	12	—85	12 dba min.	12 dba	2	B	D, HS, CS	D: n/s HS: 10 usec CS: n/s	Yes
n/s	n/s	n/s	n/s	n/s	n/s	H	n/s	n/s	Yes
n/a	14	n/s	n/s	n/s	n/s	H	n/s	n/s	Yes
n/s	12	n/s	n/s	n/s	3 two-way	B	n/s	n/s	Up to 8 for 1
n/a	12	n/s	n/s	n/s	n/s	B	Protection channel used		Yes
n/s	9	—84	n/s	n/s	2	H	D, HS, CS	D: <25 ms HS: <25 ms CS: 90 sec	No

The other portion of the receiver total noise, that generated internally, can be reduced by careful front-end design, particularly in the r-f amplifier (if one is used), the mixer, and the first i-f amplifier. The balanced mixer, for example, long used in low-noise radar receivers, is now appearing in microwave systems.

The receiver noise threshold, for 99.9% performance reliability, should be at least as low as the r-f signal level which will be exceeded 99.9% of the time, so that the noise in the channels will not exceed the desired level for more than 0.1% of the time.

Obviously, the r-f signal level, on a system basis, is also influenced by transmitter power output, and the margin between median signal level and the receiver noise threshold — the fade margin — can be increased by increasing transmitter power output. All else being equal, the fade margin can be increased 3 db by doubling the transmitter output, and 7 db by using five times the power.

Intermodulation noise, resulting from amplitude and/or phase distortion, is also contributed by both transmitter and receiver. Since it is a function of the number of channels active (system loading), and since it cannot economically be eliminated altogether, intermodulation noise is permitted to reach a given value for a given percentage of the time. It is important that the intermodulation noise be expressed in terms of system loading and referenced to a specific time base. General practice is to establish the intermodulation noise in terms of the peak system loading not exceeded by more than 1% of the busy-hour traffic. As mentioned earlier, increasing the modulation level to reduce the effect of thermal noise will increase intermodulation noise; since the transmitter noise represents the minimum attainable value, a suitable compromise is to make the intermodulation noise exceeded 1% of the busy hour equal to the transmitter noise.

Standby and diversity

After the maximum survival probability and performance reliability have been achieved in the equipment itself, the over-all reliability of a system may be increased by the duplication of equipment. Several methods involving duplication of facilities are in common use. The simplest of these is the provision of failure-sensing devices and standby equipment that is switched into service in the event of a failure in the operating equipment. This improves the survival probability only, and has no effect on performance reliability. Latterly, the principle of diversity operation, utilizing either two equipments operating on different frequencies or two spatially separated systems on the same frequency, or both, has become popular. This approach is intended primarily to improve the performance reliability, although it can also provide standby protection in case of failure, and thus affect the survival probability of the system.

The receiver outputs of a diversity system may be either switched or combined — the theoretical advantages of several diversity systems over a nondiversity system are shown in Figure 1 in terms of the Rayleigh probability distribution. It can be seen that a fade margin of 28 db is required in a nondiversity system for 99.9% performance reliability. This represents an outage of about 525 minutes per year. For 99.99% reliability (outage of about 52 minutes per year), 38 db of fade margin is required. The use of dual diversity with a combiner reduces the fade margin requirement for 99.9% reliability by over 15 db, and the requirement for 99.99% reliability by over 20 db, relative to a nondiversity system.

Like stereo, however, diversity should not be used as a means for downgrading the performance of the individual systems. If good engineering practice is followed, the fade margin requirement for a diversity system will be the same

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	Sup.										
	n/s	12	n/s	n/s	n/s	n/s	H	CS	n/s	n/s	
	n/s	10	n/s	n/s	n/s	n/s	H	D, CS	n/s	n/s	
	n/s	9	n/s	n/s	n/s	n/s	H	D	n/s	n/s	
	n/s	9	n/s	n/s	n/s	n/s	H	HS, CS	n/s	n/s	
	n/s	12	n/s	n/s	n/s	n/s	B	HS, CS	n/s	n/s	
	±0.3 db 0.3-3.4	12	—85	12 dba min.	12 dba	2	B	D, HS, CS	D: n/s HS: 10 usec CS: n/s	Yes	
	n/s	n/s	n/s	n/s	n/s	n/s	H	n/s	n/s	Yes	
	n/a	14	n/s	n/s	n/s	n/s	H	n/s	n/s	Yes	
	n/s	12	n/s	n/s	n/s	3 two-way	B	n/s	n/s	Up to 3 for 1	
	n/a	12	n/s	n/s	n/s	n/s	B	Protection channel used		Yes	
	n/s	9	—84	n/s	n/s	2	H	D, HS, CS	D: <25 ms HS: <25 ms CS: 90 sec	No	

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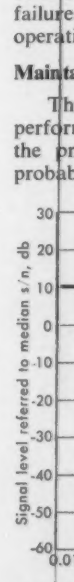

Fig. 1.
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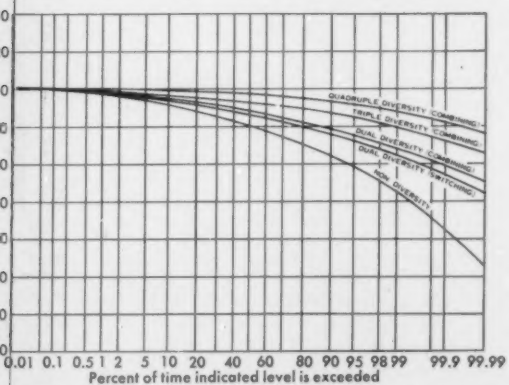
Ambient Temp. Range (°F)	Ambient Humidity Range (%)	Built-in Metering Facilities	Blowers or Fans Used	Alarms Available	Space Occupied (15)	Power Supply Options and Requirements
—4/+122	0/95	Yes	Yes	Tx–1 Rx–1	n/s	115 vac Requirements n/s
—4/+122	0/95	Yes	Yes	Tx–1 Rx–1	n/s	115 vac Requirements n/s
—4/+122	0/95	Yes	Yes	Tx–1 Rx–1	n/s	115 vac Requirements n/s
+32/+122	0/95	Yes	Yes	n/s	n/s	115 vac Requirements n/s
+32/+122	0/95	Yes	Yes	n/s	n/s	115 vac; 130/24 vdc Requirements n/s
n/s/+140	0/95	Yes	No	n/s	n/s	110/220 vac A: 400 w B, C, D: n/s
0/+105	0/95	Yes	No	Tx–3 Rx–3	n/s	Options n/s A: 900 va C: 1.8 kva B and D: n/s
0/+105	0/95	Yes	Yes	Tx–6 Rx–6	n/s	115 vac A: 3.1 kva C: 3 kva B and D: n/s
0/+105	0/95	Yes	No	Tx–4 Rx–4	n/s	100–130/200–250 vac A: 700 va C: 1.4 kva B: 1.6 kva D: 3.2 kva
0 +105	0/95	Yes	No	n/s	n/s	100/250 vac Requirements n/s
—22/+140	0/95	Yes	Yes	Tx–1 Rx–1	n/s	115 vac A: 886 va C: 1.046 kva B: 1.806 kva D: 2.125 kva

hat for a nondiversity system. This means that a diver- system with a 28 db fade margin will have a perform- e reliability of 99.9999%, or a cumulative outage time about 30 seconds per year. Under these conditions, the ure of one radio system will leave the second system rating at 99.9% reliability.

intainability and maintenance

There are other aspects of both survival probability and formance reliability which should be investigated by prospective user of microwave equipment. Survival bability, for example, must be weighed against the


QUADRUPLE DIVERSITY COMBINING
TRIPLE DIVERSITY COMBINING
DUAL DIVERSITY COMBINING
DUAL DIVERSITY SWITCHING
NON-DIVERSITY
0.01 0.1 0.5 1 2 5 10 20 40 60 80 90 95 98 99 99.9 99.99
Percent of time indicated level is exceeded

1. Theoretical advantage of various diversity systems a non-diversity system.

ntainability of the equipment — an equipment which s once a year may require three days to repair. Simi- larly, an equipment which provides a high performance reliability in the early stages of its life may demand tube replacement at frequent intervals in order that its performance be maintained. The facilities provided for rapid, simple maintenance procedures, the accessibility of replaceable parts, and the manufacturer's recommendations regarding the maintenance and servicing required for a given performance reliability, should all be taken into consideration so that an accurate picture of first- and second-order costs can be obtained.

The job of the prospective user of microwave equipment should not end with the selection of a system which provides the required performance reliability — which brings us to the "under given conditions" portion of our definition. Despite the rigid standards laid down for its design and manufacture, military electronic equipment is almost invariably subjected to regular preventive maintenance routine performed at definite intervals. Commercial microwave equipment, although it is expected to operate in severe environments for indefinite periods of time, is often maintained on a corrective, rather than a preventive basis, and is then criticized when it fails, due to neglect, to provide the required performance. A properly engineered and equipped microwave system is capable of a performance reliability equal to, or better than, that provided by any other communications medium, but its inherent capabilities will only be fully realized if it is given the attention warranted by its performance and the load it is required to carry.

Reliability is a user as well as a supplier responsibility. Like virtue, it is its own reward. END

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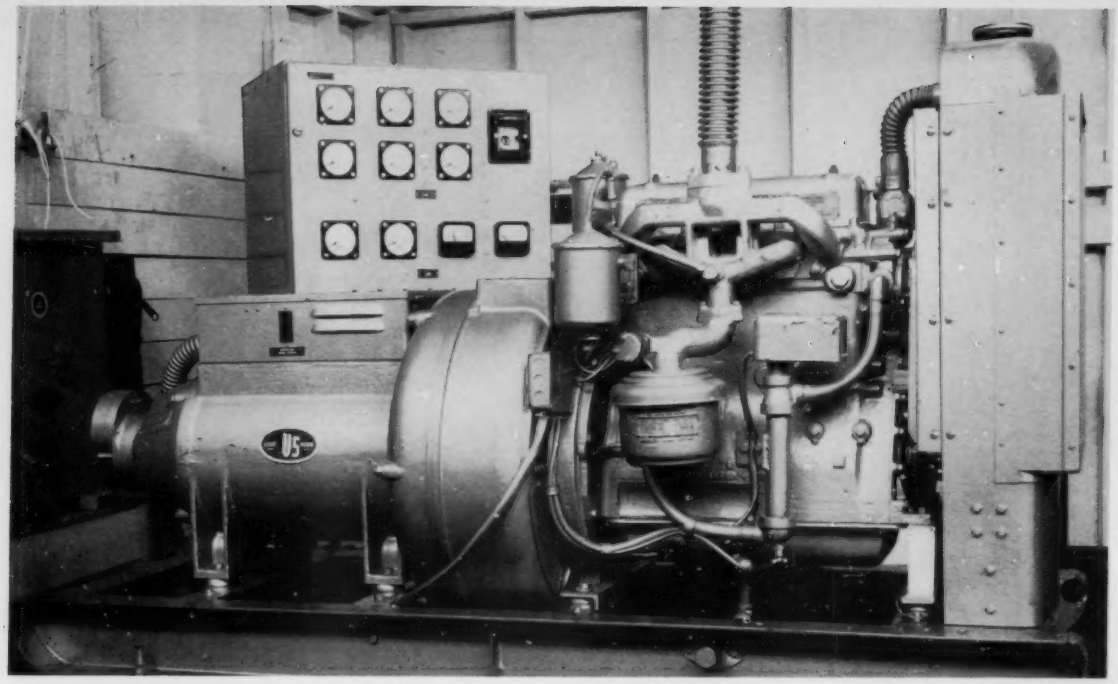
1. J. J. Naresky, "Numerical approach to electronic reliability," Proc. IRE, vol. 47, pp. 946-956; May, 1959.



Three-machine sets provide economical no-break power

JOHN CHRISTENSON*

Alternative methods of providing an emergency power source for radio equipment are described, including battery systems and engine-driven generators. The latest method, the no-break generator, is introduced and it is shown how it meets the basic need of a microwave installation.

Microwave terminal and repeater station equipment normally derives its power requirements for plate, filament and other supplies from the commercial alternating current mains. Since continuity of service is a basic requirement of the telephone and other companies who use the equipment, a reliable emergency power source is essential, to take over when the commercial supply fails. This is particularly important for remote stations, which are frequently fed by long rural pole lines subject to severe wind and icing conditions.

A few manufacturers produce transmitter-receiver equipment with options for direct current supply. These are, however, most often used by telephone companies in locations where adequate dc power is available, usually from banks of storage batteries. There are also extremely remote repeater stations too far from existing commercial supplies to justify the construction of a spur line. These are usually provided with duplicate engine-generator sets, each of which can supply the total load if the other fails.

However, the majority of stations are fed by commercial ac power, and this is the case that will be considered in this article. Two general systems of providing emergency power have been used for some time: storage batteries and engine-driven generating sets.

Battery sets have been applied to many installations. Since commercial power outages can be of fairly long duration, the means of recharging the batteries must normally be independent of the commercial source. This is achieved by providing an engine-dc generator set that is automatically started to charge the batteries when the battery voltage falls below a pre-determined level. The control may also work on a load-demand basis, or a combination of load-demand and falling voltage.

This system has a lot of merit, but it does involve a considerable bank of batteries — and batteries are difficult and expensive to maintain. Further, since the microwave equipment is usually designed for ac supply, the dc from the batteries must be converted. This can be done with a dc motor-ac generator set, vibrators, or static inverters using magnetic amplifier and/or transistor circuitry. Apart from being expensive to purchase and maintain, these sys-

(Continued on page 57)

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Antenna designs keep pace with microwave systems

RICHARD P. MATTHEWS, P.ENG.*

Canadian needs for widespread, reliable communications have necessitated improvements in radiating systems, particularly in the area of microwave parabolic antennas. These are described for both reflectors and primary radiators. Reference is also made to the trend towards package procurement of complete radiating systems from one supplier.

Canada, with its far-flung borders, its vigorous climate, and endless variety of terrain, has presented many unique problems to the communications engineer. Thinly populated by an aggressive modern people, rapid and reliable communications have been, and will continue to be, essential to its astonishing growth. Here, in the birthplace of the telephone, communication engineers early recognized the many advantages offered by radio. As a consequence, radio frequency radiating systems of high quality, electrically and mechanically, have been required. As the years go by all these requirements are becoming more and more stringent. It is the purpose of this article to briefly outline today's trends in the design of antennas and related items.

Vehicular communications. This portion of the communication market has shown the least change in the last several years. Most of the systems operate in the 150-174 mc band. Fixed station antennas with unity gain have been the order of the day. There has been some requirement for omni-directional antennas having gains from 3 to 4 db and this requirement should increase. There has been little requirement for higher gain in omni-directional antennas in this band, but as existing communication systems become larger and more complex, there should be a greater call for this type of antenna.

Because of our low population density, the vhf band has not become saturated in many areas and thus the utilization of the band from 450-470 mc has been very small. It is anticipated that activity will increase in this band in the next two or three years with a requirement for fixed station antennas having a gain of 5 to 10 db.

It is surprising that the industry has accepted for so many years the inefficient quarter-wave whip as a radiating source on vehicles. Inexpensive mobile gain antennas for roof-top mountaing at 450-470 mc have been offered to the industry with little success. Such a gain antenna for the 150-170 mc band is also feasible, but users have not demanded this type of antenna at all.

Point-to-point communications. In this category we will discuss the antenna requirements of systems operating in the frequencies below 1,000 mc. These systems usually carry relatively few channels.

The vhf band is heavily utilized for this type of service and this utilization should continue. The workhorses are the Yagi and the corner reflector, the former where gain is paramount. Because of its broadband characteristics, the corner reflector is used in many parts of Canada where hoar frost and icing conditions prevail. There has been no significant development recently in the design of antennas in this field.

The general trend toward a greater number of channels and greater reliability has started to influence the choice of antennas in frequencies above 450 mc. Even at this frequency, the corner reflector and the Yagi are being superseded by parabolic reflecting type antennas. Military requirements gave impetus to this trend. The communications network of the Mid-Canada System utilizes 10-ft diameter parabolic antennas in this band. Commercial use

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by common carriers, though limited is increasing.

Because of this trend, all types of antennas other than parabolic have virtually disappeared from the 900 mc band.

Microwave antennas. Even the meaning of the word "microwave" has changed in our changing communication scene. The general usage now signifies point-to-point communications where parabolic antennas are used. It normally does not signify over-the-horizon propagation systems.

It is in the design of the antennas for this application that we see the most revolutionary changes. These changes are found not only in the design of the reflector but also in the design of the primary radiator.

Before going into the details of the changes that have taken place in the parabolic antenna, it would be wise to pause for a minute and study the communication system requirements which have necessitated the changes.

First, the mushrooming demand for more and more circuits to be jammed on to one radio frequency carrier has meant that antennas have to be much broader-band than previously. Also, as the number of microwave hops in tandem increased, the noise distortion contribution by each hop had to be reduced; this required antennas with a greatly improved impedance match.

Second, as individual microwave systems became more complex and more systems came into operation, interaction between hops in one system and interaction between systems became more of a problem. To the antenna designer, this meant better side and back lobe suppression was required.

Third, the gain of the individual antenna has become secondary to the other performance parameters listed above. System gains, however, have remained the same. Therefore the trend has been, and will continue to be, to larger and larger reflectors.

Effects of changing requirements

These fundamental changes in the relative importance of the electrical characteristics of an antenna have caused re-assessment of the adequacy of the design of the reflector and the primary radiator.

As an example of these changes in the electrical requirements, catalogues published two years ago featured antennas for use at 2,000 mc having a bandwidth of 150 mc, with an impedance voltage standing wave ratio (VSWR) of better than 1.35 through this band. However, today's requirements are for bandwidths in excess of 200 mc with a VSWR better than 1.10 throughout this band. Antennas to meet these more stringent requirements are in service. Tomorrow the bandwidth will be even greater and the communication system user will be demanding a better VSWR throughout the wider band.

Early parabolic reflectors consisted of a wire mesh attached to a rib structure, which had a parabolic contour. In Canada the advantages of the mesh surface were never fully realized, because icing conditions are severe enough to require that the supporting structure be designed to support a solid face anyway. For electrical reasons, this type of reflector is now practically obsolete. It has been ascertained that the use of a mesh reflector gives a loss of efficiency and poorer back and side lobe suppression than that given by a solid reflector.

The primary radiator has changed from a simple two-element Yagi type radiator to slot-excited cavities for frequencies up to 2,000 mc, and to waveguide-fed horn radiators at the higher frequencies.

Another significant development in the design of parabolic antennas is the crossed-polarized radiator. In some cases this requirement comes from the equipment designer, who has decided it is better to duplex transmit and receive signals in the antenna proper rather than in a duplexer located near the equipment. In other cases the requirement stems from the advantages of cross-polarization diversity.

In this instance, the usual practice is for two receiving antennas polarized 90 deg. from each other, but located in the same reflector, to receive the same intelligence from a single distant transmitting antenna.

The most sophisticated antenna in use today is the cornucopia. This type of antenna is used almost exclusively by the Trans-Canada Telephone System in relaying television and multi-channel telephony circuits from Sydney to Vancouver. Smaller, less expensive cornucopia antennas, having similar characteristics but with some sacrifice in gain, will become available in the next year or two. This type of antenna gives good performance in that it is extremely broadband has a good impedance match, exceptionally good front-to-back ratio and good side lobe suppression.

At the beginning of this article, the term "radiating system" rather than "antenna" was stated to be the subject. Besides the antenna, this includes the transmission medium to the antenna, passive reflectors if used, duplexers, diplexers, multi-plexers and ferrite isolators. It goes without saying that the characteristics of these components must keep apace with those of the antenna with which they are associated, particularly with regard to bandwidth and impedance match. As a consequence, the trend to greater utilization of waveguide rather than coaxial line will continue.

The passive reflector has been used for some years, primarily at the top of a tower to eliminate the use of a transmission line between the bottom and the top of the tower. In British Columbia, the Pacific Great Eastern Railroad has successfully used these devices to dodge around mountains (see page 55).

Over-the-horizon tropospheric scatter. No article on communication trends would be complete without some mention of scatter antennas and associated equipment. The applications for this form of radio communication have been primarily to fill military requirements. However a commercial scatter system is in service in Labrador, another in northern Ontario and a new system is presently being installed in northern Manitoba. It is anticipated that more of these systems will be utilized to open up the Canadian north.

As in regular microwave systems, the trend is to larger antennas of better electrical characteristics. Some of the earlier military systems are presently being re-fitted with primary radiators having better VSWR characteristics over a wider band than was thought possible at the time the original system was installed five years ago. This type of propagation started with reflectors having a diameter of 28 ft. Now people talk of reflectors having a diameter of 120 ft. without even gasping for breath!

Radiating systems. Another important trend in the communication industry is the procurement of a radiating system completely from one supplier, rather than the piece-part buying of antennas, transmission line and other accessories, with the communication user or the equipment supplier tying all these various components into one radiating system. The requirements are becoming so tight that the antenna specialist is required to supply the whole system from the equipment outwards, so as to properly match the various components. The antenna industry is ready, willing and able to take on this over-all responsibility for radiating systems and thus contribute to a greater degree to the advancement of the radio communication industry in Canada. END

Modern towers and passive repeaters meet Canadian radio relay requirements

G. A. COLLINS, P.ENG.*

Towers for the support of microwave antennas are subject to stringent structural and rigidity requirements, particularly in Canada where severe wind and ice conditions prevail. The trend is to higher guyed towers for larger antennas. Manufacturers are also supplying more and larger passive reflectors to meet system requirements.

A tower supporting one or more paraboloidal antennas or passive reflectors is generally designated as a microwave tower, and in this capacity has been widely used in non-military applications in Canada.

The high rigidity requirements for twist and deflection of the antenna supporting structure and the large horizontal thrust imposed on the tower by wind on the microwave antennas are the main factors distinguishing microwave towers from other antenna supporting structures used in the communications industry.

Over 300 of these towers have been erected in Canada, largely since January 1956, and the year 1960 will probably see close to 100 more added to the total. This tremendous increase in the use of microwave communications parallels development in the United States, where the number of stations, and therefore towers, has increased 35-40% every year since 1950. One new microwave system alone employing over 160 towers will be installed in 1960 and 1961.

At the present time microwave towers, spaced approximately twenty-five miles apart, extend from Victoria, B.C., to St. John's, Newfoundland. Over some paths, such as Montreal to Moncton and Windsor to Toronto, there are two separate strings of towers. In addition, British Columbia, Alberta, Saskatchewan, Manitoba and Quebec have substantial north/south routes as well; Labrador and the Yukon will shortly be added to this list.

It is significant that no sooner is a tower erected at an extremely remote site, the demand for communications services often makes this the starting point for future planning.

Microwave towers may be either the guyed or the self-supporting type; various factors tend to determine which of the two is used at any given site. Such items as the desirability of locating a microwave station as close as possible to existing communication facilities, small available space, and the high cost of land generally favour the use of self-supporting towers. Where high towers are needed and in areas where land is readily available and inexpensive, first consideration should be given to guyed structures. Unless there are overriding considerations such as obstruction of parking areas or esthetic problems, it is usually the over-all cost which determines the type of tower used.

In the early days of microwave communication, from five to eight years ago, with the exception of the transcontinental radio relay systems, the industry used four- and six-foot diameter paraboloidal antennas and 4 ft x 6 ft, 6 ft x 8 ft or 8 ft x 12 ft passive reflectors mounted on steel towers. Now the trend is to larger antennas and reflectors: the 10-foot diameter paraboloidal antenna and 10 ft x 15 ft passive reflector are the rule, with some reflectors as large as 12 ft x 17 ft and even 15 ft x 21 ft.

Design considerations

Some of the major parameters in the design of microwave towers are the number and size of the microwave antennas to be supported, their alignment with the wind, the elevations at which they are to be mounted, and the number and size of transmission lines, conduits and ladders to be mounted on the tower. In some towers, even with

*President and General Manager, Micro-Tower Limited, Scarborough, Ont.

four 10-foot diameter paraboloids, the total horizontal thrust due to wind on iced transmission lines, conduits and ladder exceeds the horizontal thrust on the antennas.

The wind velocity for which the tower is to be designed and the thickness of ice coating it has to withstand are of primary concern to the tower designer, particularly when it is realized that the wind pressure increases as the square of the velocity and that a thread running vertically up the tower becomes two inches wide when the tower is coated with one inch of radial ice.

A typical example of the great variation in loads that can result from the application of wind forces can be seen from the case of a 300-foot guyed tower supporting one 10-foot diameter paraboloidal antenna. When subjected to a 150 mph (90 psf) wind with no ice, the tower has a calculated base load of 107,000 lb, but when considered with a 50 mph (10 psf) wind and 4 in. of radial ice the base load rises to 299,000 lb.

Of equal importance to the structural requirements in the design of microwave towers are the rigidity requirements. A tower twist of 0.5 deg and a deflection of 0.25 deg are frequently specified. The vertical deflection, which is the departure of the tower from a straight line, is the more difficult to achieve. In the case of the guyed tower it has to be calculated in conjunction with the structural design, and frequently results in several trips around a narrowing circle of calculations. This is further complicated by the fact that the rigidity is normally determined for a wind velocity of 70 mph with no ice on any part of the structure, while the structural requirements are frequently quite different.

Future trends

As a result of the development of larger paraboloidal antennas, lower loss transmission lines and higher transmitter power output, coupled with favourable experience with high microwave towers, the trend at this time is to consider a higher tower close to access roads and commercial power, rather than locating the tower on an isolated hilltop where the cost of constructing a private road can be enormous. A few years ago 300 ft was considered to be the maximum practicable height, whereas 400-500 ft is not uncommon today and in some cases even higher towers are being built.

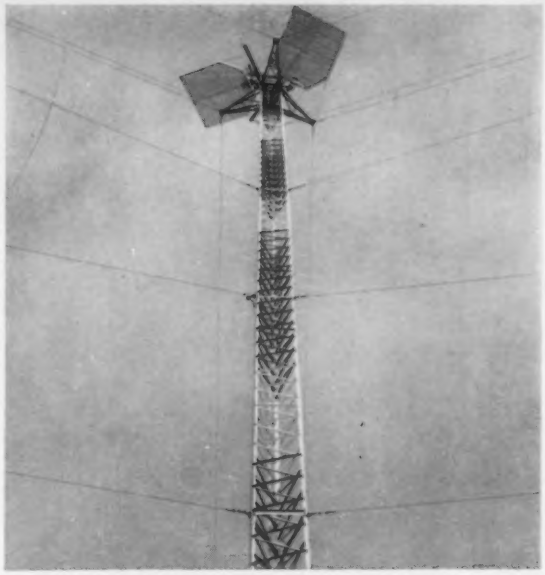
There is also a definite swing away from the self-supporting type of tower as the communications industry realizes that the guyed tower can frequently be quite as satisfactory at considerably lower cost, particularly for heights of 150 ft or more.

Passive repeaters

By far the most glamorous of microwave antenna systems are passive reflectors. These are simply large flat metal signboard type structures and are frequently installed in remote locations to reflect, as a mirror does light rays, radio frequency energy from one station to another. They are also used, particularly at frequencies over 6,000 megacycles, to eliminate the transmission line between the bottom and the top of a tower, the antenna being located at the base of the tower and aimed upward toward the reflector, which then sends the energy along the required line-of-sight.

It is in the use of these devices, which are completely passive in that the closest electronic equipment is usually one-half to three miles away, that the microwave systems engineers have demonstrated their ingenuity and daring.

Using passive repeaters, microwave paths have been established around buildings, natural obstacles such as a hilly ridge and through twisting mountain valleys. In one case in Canada a carom shot was actually made between two passive repeaters located a few hundred yards from each other on top of a 6,000-foot mountain. In another, a double carom shot was made from three passive repeaters on a ridge.



This three hundred-foot tower supports two passive reflectors, each measuring ten feet by fifteen feet.

It is the first look at the initial cost of a passive repeater which is staggering. In a fairly typical setting the cost can be anything from $18,000 to $40,000 for a structure about 35 ft high supporting a 20 ft x 24 ft reflecting surface, completely installed including foundations and survey work. When it is realized that some of these repeaters are located on otherwise inaccessible ridges or mountains and that everything (including the initial surveyors, the concrete contractor and all his materials, the structure, the erector and his tools, and the final alignment technicians) has to be taken in by helicopter at a cost of about $108 per hour of flying time, that the total cost comes into its proper perspective.

However, the advantages to be gained are prodigious and can sometimes be equivalent to eliminating two active microwave stations which, fully equipped, can cost from $80,000 to $100,000 apiece.

The largest of these devices in use in Canada is 20 ft high and 30 ft wide; many have been made for use in the United States and Hawaii that are 30 ft x 30 ft. One manufacturer alone has made and installed over 40 passive repeaters — an indication of the industry's acceptance of this device as a solution to difficult or impossible line-of-sight problems. The mountainous terrains of British Columbia and Labrador lend themselves to the exploitation of passive repeaters; it was in British Columbia that they were first used in Canada.

The use of microwave radio relay systems has already extended modern communication facilities to the fringes of the populated areas of Canada, resulting in a demand for services in these areas greater than had ever been anticipated. The tower fabricators of Canada are poised for the requirements of the logical extension of these facilities into the more remote areas of the country, and are prepared to design structures to support larger antennas or passive repeaters under conditions of heavier wind and ice loading as these areas are reached. END

Microwave expansion will demand careful spectrum management

The future of microwave radio communications in Canada is evaluated for frequencies in excess of 890 megacycles. A great increase is forecast in both the number and type of applications, accompanied by a corresponding increase in the problems of frequency allocation and interference between systems. It is concluded that allocation within the fixed service bands for specific services is a fundamental need.

S. BONNEVILLE, P.ENG.*

In this article an endeavour will be made to evaluate the future field of use of microwave radio in Canada. For this purpose it is proposed to consider the frequency band above 890 megacycles.

A review of the testimony presented before the Federal Communications Commission in the United States gives some indication of the technical advances in theory, methods, devices and propagation in the microwave field. One exhibit shows that in the period 1950 to 1955 when the highest frequency in commercial use was 6,000 megacycles, research was concerned with frequencies up to 50,000 megacycles. Since 1955 the highest commercial frequency has risen to 11,000 megacycles, and research is now concerned with frequencies up to 100,000 megacycles. It will be seen that research is many years ahead of the commercial application of frequencies. This gives some indication of what we may expect in the future use of these new bands.

Although at one time the microwave band seemed unlimited, there now appear to be certain ceilings to the use of frequencies for long-haul applications. This factor, together with the need of frequencies for military, scatter, satellite communications and similar applications, and the possibility of interference from high-powered radio installations, presents a confused picture to anyone trying to evaluate the future use of the microwave band. No doubt these considerations will be resolved, but to avoid headaches they should be resolved as soon as they are recognized.

It now appears that for long-haul applications, rain attenuation and other factors will, for the present, limit the top frequency to some 10,000 megacycles. No doubt this limit could be extended by using special techniques, some of which are now under development. For short-haul applications in the common carrier field, there are possibilities of systems operating above this frequency limit. These include inter-office trunks, circuits between line concentrator devices and central offices, and circuits to customer premises.

In addition, wide-band facilities used for television broadcasting will be extended. The utilization of television for non-broadcast purposes such as closed-circuit applications has only started to develop. "Seeing at a distance" is

*Staff Engineer—Radio, The Bell Telephone Company of Canada, Montreal.

so valuable a tool that a tremendous growth in the field seems certain. It appears likely that television will develop in the future much as telephone has in the past half century.

The foregoing factors are above and beyond the continuing growth of intercity telephone facilities. This rate of growth can be expected to increase to meet the needs of direct subscriber dialing, and the civil and military requirements for data transmission.

Extensive networks are being developed in connection with the defence program. Higher speeds and the need for greater reliability will result in the use of more and more frequencies; the Ballistic Missile Early Warning System (BMEWS) represents the start of this expansion. Similar developments may be expected in the field of artificial satellites, lunar probes and other space vehicles. New radar systems are under development for civil and military applications, which will require an ever-increasing band of frequencies in the microwave spectrum. Talks given at the IRE National Convention last March indicated that future frequency needs will be many hundreds of times greater than those in present use.

In the past many of the services operating below 30 megacycles have been transferred to the VHF and UHF bands. One would also expect that a similar situation will exist in the higher bands. Services now using scatter propagation at frequencies below 890 megacycles will no doubt be provided by microwave in the future.

With the anticipated growth of systems operating in the microwave field it is important that early consideration be given to the possibility of interference between systems, particularly those in the same frequency band. Another serious source of interference which will require close co-ordination is that from high-power radar systems for military and non-military use. These are growing rapidly in number and power output.

The use of high-power radar and scatter stations also introduces the problem of hazards from radiation and points up the need for suitable protective measures. National standards should be established through suitable codes prepared by the Canadian Standards Association.

In the United States definite sub-allocations within the fixed service bands are made for specific services and this has permitted the manufacturers to develop suitable equipment in these bands. This is not the case in Canada, where it is felt that more efficient and flexible use of the spectrum can be made by broader allocations and by assigning frequencies on a geographic basis. To date this has worked out very well. Nevertheless, in the writer's view a reassessment of this position is urgent, because of the unexpected growth in the microwave field. This is one of the significant recommendations of the Microwave Committee of the Canadian Radio Technical Planning Board, which may in due course be forwarded to the Department of Transport.

Some work has been done to make more efficient use of the frequency spectrum by crowding the same amount of information into narrower bands. This effort will no doubt be continued in the future as more advanced techniques are developed.

In summary, we may expect a large increase in the frequency usage between 890 and 10,000 megacycles within the next few years, with some development above 10,000 megacycles. To insure efficient use of the spectrum it is essential to provide co-ordination between adjacent microwave systems and between these systems and radar installations. Allocation within the fixed service bands for specific services would seem to be fundamental to the stable and orderly development of equipment hand-in-hand with efficient spectrum use. With respect to equipment development, a systematic approach toward the integration of narrow bandwidths also seems essential. END

Three-machine sets provide economical no-break power

(Continued from page 51)

tems still have one basic fault: there is a definite break in the supply to the radio equipment during the period of load transfer.

The other system that has been widely used consists simply of an engine-driven ac generator, together with controls for starting the engine and connecting the generator to the equipment in the event of a power failure. The engine may be fueled with diesel oil, gasoline, natural gas, propane, or liquefied petroleum gas (LP).

In addition to the automatic load transfer switch, various engine controls are needed. These include a relay to close the starter circuit and, depending on the type of engine, energize the ignition coil, remove the magneto ground, or (for diesel) operate the fuel control solenoid; a device to open the cranking circuit when the engine comes up to speed; a time-delay relay to interrupt the cranking circuit if the engine fails to start after a set period; and, in the case of gasoline engines, an automatic choke. Timing relays are also commonly used in conjunction with the transfer switch to avoid starting the engine when an outage is of very short duration, or to delay return of load to the mains in case the restoration after an outage is only temporary.

Although engine-driven generators have served the communications industry well as emergency power sources, they still require a definite time for starting and running up the engine before they take over the load, and thus do not meet the basic requirement of a high-reliability microwave system: no interruption of service in the event of power failure. This type of "no-break" emergency power, as it is called, was only available from the combination of large banks of batteries and associated equipment until the advent of the three-machine set.

This type of set was developed and perfected in the years following 1951 to meet the specific needs of the microwave industry. It comprises an engine, electric clutch, ac motor, ac generator and a flywheel; the motor, generator and flywheel are mechanically coupled.

The motor is normally fed by the commercial supply and drives the generator and flywheel, the microwave equipment being powered by the generator output. On failure of the commercial power, the motor is disconnected, but the flywheel continues to revolve and drive the generator. At the same time, the clutch is engaged and cranks the engine. After starting, the engine drives the flywheel, motor and generator to furnish continuous power. On return of commercial power, the motor is re-connected, the clutch disengaged, and the engine shut down.

A considerable amount of development work was carried out on these sets, following tests on the prototype. Each of the components and controls is now specifically designed for this application, resulting in a small, compact, relatively light-weight, but rugged set that can provide dependable service without requiring frequent adjustments or maintenance.

The performance obtained meets all the requirements of the communications engineers. During engine starting the frequency only drops 1½ to 2 cps, and the voltage drop of 4 to 5v on the earlier designs has now been eliminated in the newer sets with static voltage regulators and exciters. In the U. S. Motors case, they are known as Micro Power no-break generators and are available in 1.5, 3, 5, 10, 15, 20 and 50 kw ratings. Engines can be fueled by gasoline, natural gas, propane or LP for all sizes, and by diesel for the higher ratings. END

CANADIAN ELECTRONICS ENGINEERING

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For your library

Automation handbook stresses role of analog and digital computers

Handbook of Automation, Computation and Control. Volume 2.

Edited by E. M. Grabbe, S. Ramo and D. E. Wooldridge; John Wiley & Sons, Inc., New York; 1050 pp; $17.50

Volume 1, Control Fundamentals, of this three-volume handbook was reviewed in the February 1959 issue of CEE.

Recognizing the steadily increasing importance of computing in research, development, production, real time process control, and business applications, the editors have devoted Volume 2 entirely to the design and use of analog and digital computers and data processors. In addition to covering the status of knowledge today in these fields, there are chapters on unusual computer systems, magnetic core and transistor circuits, and an advanced treatment of programming.

Volume 2, which is subtitled Computers and Data Processing, is divided into six major sections for ease of reference. These are: computer terminology, digital computer programming, the use of digital computers and data processors, design of digital computers, design and application of analog computers, unusual computer systems. Forty-one specialists have contributed to the total of 31 chapters.

Volume 3, not yet published, will deal with Control Systems and Components.

Nucleonics Fundamentals

D. B. Hoisington; McGraw-Hill Co. of Canada Ltd., Toronto; 410 pp; $10.95

This book has been prepared for use in a course given at the U. S. Naval Postgraduate School. The purpose of the course is not to train nuclear physicists or engineers, but rather to present at the undergraduate level a broad view of the accomplishments, applications, problems, and limitations associated with radioactivity, nuclear reactors, and other nuclear devices.

The author has followed his avowed purpose quite well and produced a text that is a good introduction to the subject. While some chapters deal with things quite unrelated to electronics, the average electronics engineer would gain a much better grasp of the over-all subject by studying the entire text. Many references are given, permitting the reader to delve more deeply into any area of particular interest to him. There also are problems at the end of each section, with answers in the appendix.

In logical fashion the author has started with basic fundamentals of matter and energy, then proceeded up through atomic structure and nuclear structure before discussing equipment, fission processes, etc. Considering the scope of the text, the author has done a good job.

Electronic Circuit Theory

Zimmerman and Mason; John Wiley & Sons, Inc., New York; 564 pp; $10.75

Reviewed by A. G. Roberts, Maclean-Hunter Publishing Co. Ltd.

This book is one of several resulting from a recent revision of the Electrical Engineering Course at The Massachusetts Institute of Technology. Authors H. J. Zimmerman and S. J. Mason, are Professor and Associate Professor of Electrical Engineering at M.I.T. This book, along with the others, although put together in the form of a text for use on their courses, might be described as a report on a research program aimed at the evolution of an undergraduate core curriculum.

In this book the authors deal primarily with methods of analysis of electronic circuits through the use of circuit models. They place special emphasis on the development of piecewise-linear models suitable for large signal operation. They have devised models to approximate the characteristics of diodes, triodes, pentodes, transistors and other control valves. Resistive models for electronic devices are synthesized.

In addition, the book contains extensive geometrical and graphical interpretations of analyses using locus points to show the effect of circuit and signal on device operation. It covers the basic circuit functions in chapters on rectification and detection, wave shaping and amplification and waveform generation.

Publishers' new releases

Digest of Literature on Dielectrics

Volume 22 covering 1958; Printing and Publishing Office, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N.W., Washington 25, D.C.; $5.00 (U. S.)

Published by the Conference on Electrical Insulation, this book covers literature dealing with the fundamental and applied aspects of dielectrics and dielectric phenomena published in United States and foreign books and journals during calendar year 1958. Sample chapter headings are: Instrumentation and measurements; Table of dielectric constants; The breakdown of dielectrics; Ferromagnetic materials; etc.

Writing and Publishing Your Technical Book

The publishers of this book believe that many potentially successful authors hesitate to contact publishers with a manuscript idea because they do not understand the normal procedures. To overcome the problem, they are offering this 50-page manual free of charge. Write to Dodge Books, F. W. Dodge Corp., 119 West 40 Street, New York 18, N.Y.

Journal of Research of the National Bureau of Standards

The Journal is being divided into four sections, each available upon subscription from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C.

Section A, Physics and Chemistry: issued six times a year at $4.75 per year. Major emphasis will be on standards of physical measurement, fundamental constants and properties of matter.

Section B, Mathematics and Mathematical Physics: issued quarterly at $2.75 per year. It will present studies and compilation designed mainly for the mathematician and theoretical physicist.

Section C, Engineering and Instrumentation: issued quarterly at $2.75 per year. This will report results of interest chiefly to the engineer and the applied scientist.

Section D, Radio Propagation: issued six times a year at $4.75 per year. It will report research in radio propagation, communications, and upper atmospheric physics.

Reactance slide-rule

This plastic slide rule allows the user to determine resonant frequency of a circuit knowing inductance and capacitance, or to select various inductances and capacitances for a desired frequency. The slide rule also has provision for computing inductive and capacitive reactance as well as inductance and capacitance of resonant circuits from 1 mc to 1,000 mc.

Price is $1 from JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N.Y.

Masers

J. R. Singer; John Wiley & Sons, Inc., New York, N.Y.; $6.50

Dr. Singer undertakes to summarize the years of research that culminated in the maser's discovery, to provide a survey of how the device works at the moment, and to indicate the steps being taken to improve it.

New products

Rotary switch (Illust.) 110

Ledex BD2E circuit selector weighs less than 3 oz. and measures only 1.5 in. long and 1.375 in. in diameter. It can be used for stepping, counting, programming, circuit selecting, and homing. It can be either self-stepped or externally pulsed, and is actuated by a Ledex No. 2 rotary solenoid. The switch can hold up to four 12-position circuit wafers, with 2, 3, 4, 6 or 12 electrical position selective control. Wire sizes are available to accommodate 3 to 300 vdc, 1,000 volts rms Hi-pot. Hermetically sealed models are also available.

Marsland Engineering Ltd., Kitchener, Ont.

Resistance wire (Illust.) 111

Hoskins alloy 815-R resistance wire exhibits resistance stability over a wide temperature range, and stability over extended time at elevated temperature. The photograph shows typical curve of percent change in resistance versus temperature for alloy 815-R. The line drawing shows stability of resistance and temperature coefficient during MIL-9444 (USAF) resistor load life test.

Hoskins Alloys of Canada Ltd., Rexdale, Ont.

Low frequency waveform generator 112

Servomex low-frequency waveform generator type LF. 51 generates a very wide variety of electrical test signals over the range of frequencies encountered in servomechanisms, process controllers, and mechanical systems in general. It generates sine waves from 500 cps down to 0.0005 cps (one cycle every 33 minutes). It generates square waves and pulses of durations 100 usec up to 1,000 sec (rise time 10 usec, 10-90%). It also generates ramp functions, triangular, sawtooth, trapezoidal, and sine-squared pulses.

Other features include a facility for generating one half cycle, or one complete cycle, as well as continuous operation; plug-in nonlinear shaping unit that can be modified to simulate almost any desired function; decade dials for speed and accuracy of setting; low distortion on all waveforms.

The Glendon Instrument Co. Ltd., Toronto.

Ferrite variable attenuator 113

This ferrite type of electro-magnetically controlled attentuator has been designed for remote control use where an increase in the dynamic range of radar systems is desired. Weighing less than 19 ounces, its frequency range is 8,500 to 96 mc with a maximum insertion loss of 0.5 db.

Airtron Canada Ltd., Toronto.

Commercial silicon diodes 114

These low-cost, high temperature, 400 piv-rated silicon diodes have been designed for television, radio and commercial equipment applications where high temperature is called for. Units are operable to 70 deg C ambient temperature (100 deg C case temperature). The 2E4 diode is rated at 200 ma at 400 piv, and the 5E4 diode is rated at 350 ma at 400 piv.

International Rectifier of Canada Ltd., Ottawa.

Two-variable recorder 115

Houston Instrument Corp. model HR-92, x-y recorder, utilizes standard 8½ in. x 11 in. graph paper for ease of filing and reference. The new recorder features simple, rugged design and uses self-balancing potentiometer servos to assure 0.5% accuracy, and drift-free performance at available sensitivities of up to 1 millivolt per inch. Pen speed is one second full-scale in either plane without overshoot.

A. C. Wickman Ltd., Toronto.

Digital position indicator 116

Zerotron is an electronic device which provides straight decimal display of the position of a rotary or linear moving member with respect to any preselected arbitrary origin. It produces a clear display of position in any desired number of digitis preceded by a plus or minus sign indicating direction of movement from the origin. Digits are one inch high, backlighted white or black figures legible from distances up to 20 feet. Manual

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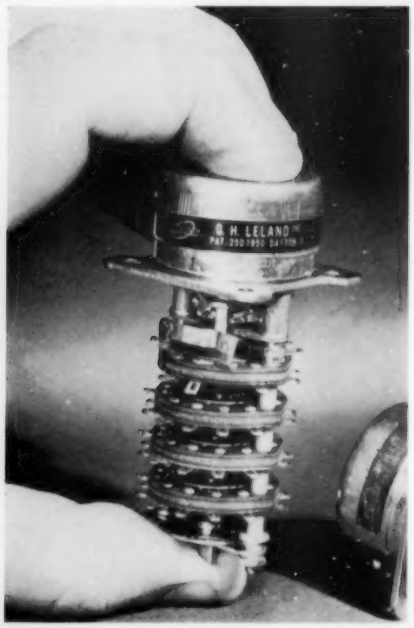

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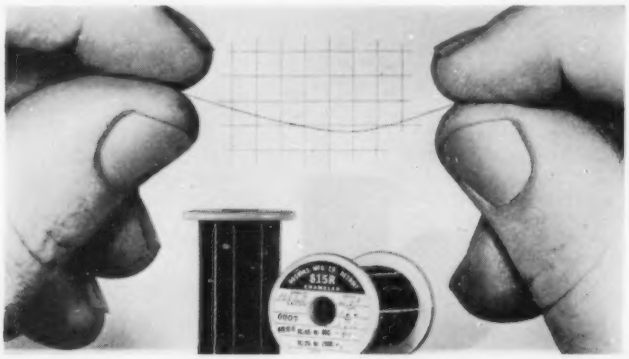
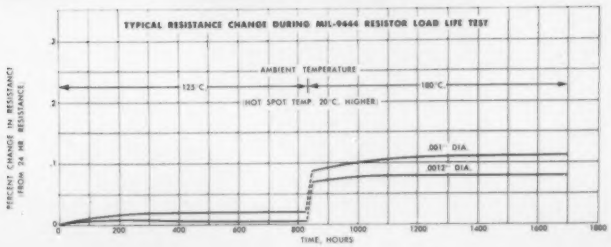




origin selection is provided by a row of selector switches which are used to zero-set the display to any desired origin. Input is from an analog-to-digital converter slaved to the moving member. Of modular design, each Zerotron digit is processed by a separate transistorized module permitting the unit to be supplied with the appropriate capacity for any custom application.

Canadian Pratt & Whitney Aircraft Co. Ltd., Longueuil, Que.

Magnetron pulse modulator 117

Bomac pulse modulator BL-P-030 is capable of powering small magnetrons requiring inputs of up to 10 kw peak at a duty cycle of up to 0.002. Pulse widths from 0.1 to 2 usec can be supplied. Meters are provided for pulse voltage, average magnetron current, and magnetron filament current. Jacks are also provided for monitoring peak pulse current, pulse voltage and the trigger repetition rate.

R-O-R Associates Ltd., Don Mills, Ont.

Computer memory element 118

This new device introduced by Transitron and called the Transwitch, is essentially a latching device which, when turned on, stays on after the turn-on signal, has been removed. Similarly, when turned off, it stays off after the turn-off signal has been removed. The unit acts as a memory" in that it remembers the last signal instruction given it without the destructive read-out problem associated with magnetic memory elements. These devices are designed for operation in the 2-10 ma range at voltage up to 20 volts. This takes in the essential range for logic type devices.

Adams Engineering Ltd., Montreal.

Air core inductors (Illust.) 119

Air Dux air core inductors have been designed specifically for prototype or amateur rf transmission use. They may be used for pi output circuits, conventional ic output circuits, interstage and oscillator circuits.

The series consists of a standard coil type, a variable pitch type and an indented type, in a range of diameters from ½ in. to 3 in. They are constructed of tinned (silver or formvar) copper wire wound on large low-loss polystyrene rods.

Len Finkler Ltd, Toronto.

Electronic vacuum pump (Illust.) 120

Series 150 UlteVac electronic high-vacuum pumps are suitable for general laboratory use, vacuum-tube processing, thin-film work, etc. Compact and efficient, these pumps with magnet (as illustrated) weigh 13 lbs and have dimensions of 6¼ x 7¾ x 5 in. They produce clean ultimate vacuums below 1 x 10^{-9} mm Hg.

Based on cold-cathode pumping structures, the series 150 includes a model 150E which contains a replaceable multi-filament evaporator, permitting the injection of additional titanium. Pumping speed for this model is 10 liters per second, for the standard units 5 liters per second. A roughing vacuum of 15 to 20 microns is required only for starting, after which the system may be sealed off.

Features include a compact all-metal coupling with rotatable flanges to permit any desired orientation of the pump. In operation, pumps draw current in a linear relationship with pressure, permitting the pump to double as a vacuum gage.

Ultek Corp., Palo Alto, Calif.

Multicircuit toggle switch 121

This toggle switch containing four poles occupies less than 1 cu. in. of space below the panel. The bat handle of the switch is maintained in one of three positions with the centre position off. Each pole of the switch element is rated at 6 amps, 125/250 vac, 30 vdc, resistive and 3 amps, 30 vdc inductive. Weight is approximately 1 oz.

Electrosnap Corp., Chicago.

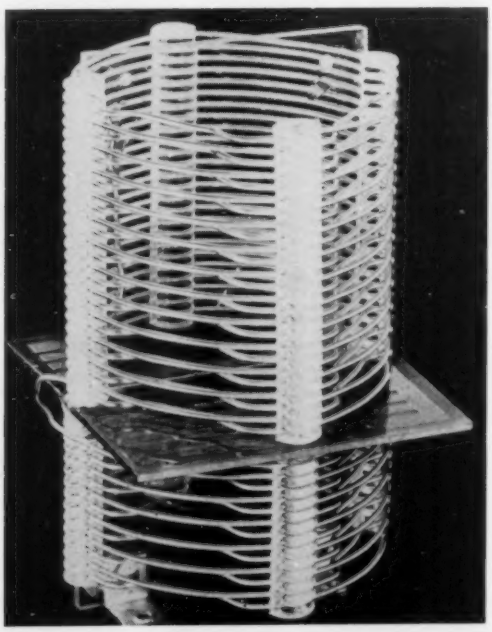
Magnetic ink 122

This magnetic ink has been designed for use in conjunction with high speed data processing equipment. It is particularly applicable to the newly adopted check interpreting systems now being installed in many banks.

Columbia Ribbon & Carbon Mfg. Co., Colitho Div., Glen Cove, N.Y.

(Continued on page 62)

119



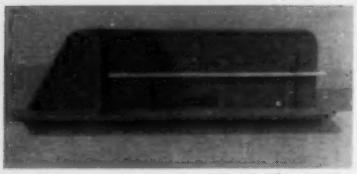
For further information on New Product items, use the Reader Service cards on pages 77 and 78.

120

New products—cont.

Train antenna 123

Model 221 antenna is a specially designed low clearance antenna for locomotives. Its height is 6¼ inches. It is a notch plate radiator with vertical polarization. Frequency range is 152-174 mc; impedance is 50 ohms; bandwidth is 1.4 mc (for vswr less than 2);



gain is unity relative to a quarter wave unipole; power rating 200 watts.

Sinclair Radio Labs. Ltd., Toronto.

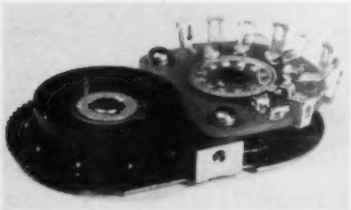
Stable dc amplifier 124

Fielden dc amplifier having a stability of 0.1% has application in strain gauge systems, computers and temperature control systems where a saturable core is used. The amplifier can be supplied in chassis form or in a weather-proof sheet steel case and has plug-in ranging units which cover standard ranges from 2 milliamps output for 5 millivolts input, and 15 milliamps output for 65 millivolts input. It is potentiometric in operation and responds to a change as small as one microvolt at the input. No measurable change in the output occurs when a resistor in series with the input is varied between 0 and 50 ohms or even higher. The output load resistance can be as high as 3,500 ohms.

Measurement Engineering Ltd., Arnprior, Ont.

Thumbwheel-operated switches 125

Grigsby Co. Inc., has introduced a series of thumbwheel-operated switches for those applications where panel space is at a premium. Switches are available in 10 and 20 position forms with larger configurations possible on special order. Thumbwheels can be supplied with any combination of letters, numerals and



special signs. Indications may be illuminated.

Lake Engineering Co. Ltd., Scarborough, Ont.

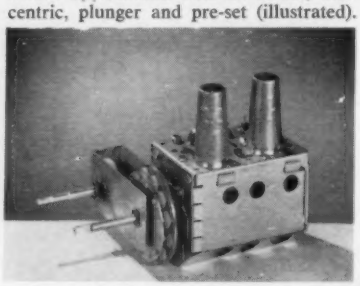
Phase generator 126

Phase generator model PG-31 is an electro-mechanical rotating transducer for application in the field of analog or digital measurement and monitoring of shaft revolutions. The normal technique employed is that of relating the generator output frequency and phase to those of a known ac reference signal. Model PG-31 generates 3 sinusoidal cycles per shaft revolution which permit it to measure phase and revolutions of slowly rotating shafts. It can also be used at very high shaft speeds. Output signal amplitude at 400 rpm (20 cps.) is 0.12 volts; at 1800 rpm (90 cps) is 0.15 volts; at 18000 rpm (900 cps) is 0.55 volts. Output impedence is approximately 200 ohms.

Presentey Engineering Products Ltd., Ottawa.

Television tuner 127

Model 500 tv tuner features individually adjustable coils for all channels and all circuits. A variety of circuits is offered, including tetrode, cascode, and super cascode in 'hot' and 'cold' versions. It is also available in a variety of fine tuning applications such as off-set, concentric, plunger and pre-set (illustrated).



The pre-set fine tuning package can be added to the tuner to give automatic fine tuning. Less than 1¼ in. is added to the overall length of the tuner. Remote control may be added where desired.

General Instrument—F. W. Sickles of Canada Ltd, Waterloo, Ont.

Prototype resistor kit 128

This kit contains all necessary tools, materials and instructions needed for winding prototype quantities of precision resistors. It contains bobbin winding machine, resistor wire, bobbins, lugs, tools and miscellaneous supplies. Instructions allowing a technician to learn the techniques of resistor manufacture facilitate use of the kit. Sufficient materials are furnished to make more than 200 special resistors.

Resistron, Pasadena, Cal.

Quick-disconnect connectors 129

Gremar QDS connectors are weatherproof, quick-disconnect types, designed for use with medium sized coaxial cables. They employ a three ball positive-locking coupling and feature metal-to-metal cable clamping construction. These connectors have a nominal characteristic impedance of 50 ohms, a peak operating voltage of 1,000, and may be used at frequencies up to 10,000 mc.

Alpha Aracon Radio Co. Ltd., Toronto and Desser E-E Ltd., Montreal.

(Continued on page 65)

Completely CANADIAN MADE

PANEL MEASURING INSTRUMENTS

PORTABLE AND LABORATORY INSTRUMENTS

ELECTRONIC INSTRUMENTATION

Only a complete Canadian instrumentation facility can offer the kind of service Canadians need. Bach-Simpson Ltd. *is* complete — in research, design, tooling and manufacture.

If our standard line of instruments, complete as it is, won't meet your requirements, ask us to demonstrate the unique combination of skills we can offer in the design of specialized instrumentation to meet your specific problem.

Others have, and have been completely satisfied!

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IN 1958

the only Award presented by the I.R.E. Canadian Convention was made to Bach-Simpson Limited. This, the first Award ever given by the Convention, recognized the 2610 Wide Band Laboratory Oscilloscope as the most outstanding new Canadian development exhibited in 1958.

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The Bach-Simpson Frequency Controller-Indicator is designed to indicate and control by a sampling method, the frequency of a power generating system. The same control principle can be applied to any quantity (i.e. voltage, temperature, etc.), which can be indicated on a switchboard meter.

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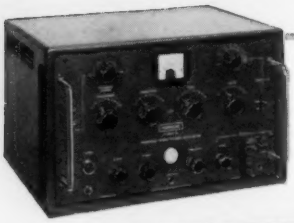
For further information mark No. 17 on Readers' Service Card

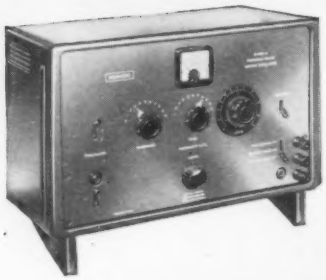
"Here are four of the most STABLE and ACCURATE variable-frequency OSCILLATORS"



D-890-A (with crystal check)
Frequency: 1c/s to 111.1kc/s
Accuracy (max.): 0.05%; 0.005% at spot frequencies
Output (max.): 126v into 8k ohms or 24v into 600 ohms

D-880-A (2-phase)
Frequency: 0.01c/s to 11.2kc/s
Accuracy: 0.2% above 5c/s; 2% at 0.01c/s
Outputs: 10v into 10k ohms and 600 ohms

D-695-A
Frequency: 10c/s to 31.2kc/s
Accuracy: 0.2% above 100c/s; 0.3c/s at 10c/s
Output: 10v into 10k ohms; 2.4v into 600 ohms



D-888-A (Analyser/Oscillator)
Frequency: 200c/s to 650kc/s
Accuracy: 2%
Output (OSC): 2.5v into 600 ohms

Write for Publications 130, 136, 137 & 138

Models cover a frequency range from 0·01 c/s—650 kc/s

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Defence contracts

Unclassified electronics contracts for $10,000 or more have been awarded to the following Canadian firms by the Department of Defence Production. A figure in parenthesis indicates the number of contracts, the amount being the total value.

September 16-30, 1959

- Ampex American Corp., Ottawa, equipment, $14,663.
- Anton Electronics Labs. Inc., Ajax, Ont., radiacmeters, $13,756.
- Burgess Battery Co., Niagara Falls, Ont., batteries, $19,375.
- Canadian Arsenals Ltd., Ottawa, spares for radar sets, $35,000.
- Canadian Aviation Electronics Ltd., Winnipeg, installation of radio equipment, antennas and associated accessories, $29,960.
- Canadian General Electric Co. Ltd., Toronto, components, $12,334.
- Canadian Marconi Co., Toronto, tubes, $21,322.
- Collins Radio Co. of Canada Ltd., Toronto, components, $205,658 (2).
- Computing Devices of Canada Ltd., Ottawa, equipment, $44,156; radar equipment, $151,637; film analyzer, $61,058.
- Domac Technical Sales Ltd., Ottawa, radar test sets, $10,800.
- Industrial Electronics of Canada, Streetsville, Ont., development contract, $10,549.
- Instronics Ltd., Stittsville, Ont., oscilloscopes, $34,650.
- Northern Electric Co. Ltd., Belleville, Ont., installation of radar sets and radar conversion sets, $400,000.
- Northern Electric Co. Ltd., Ottawa, spares for teletype equipment, $43,582; installation of communication equipment, $19,627.
- Radionics Ltd., Montreal, radiacmeters, $21,190.
- Ray-O-Vac (Canada) Ltd., Winnipeg, batteries, $12,497.
- RCA Victor Co. Ltd., Montreal, mobile microwave equipment, $1,082,794; dismantling and reinstallation of microwave equipment, $15,353; reinstallation of communication facilities, $12,991.
- TMC (Canada) Ltd., Ottawa, components, $12,930; radio transmitters, $38,828.

October 1-15, 1959

- Ahearn & Soper Co. Ltd., Ottawa, radiac equipment, $53,693.
- Bayly Engineering Ltd., Ottawa, signal generators, $41,867.
- Beaconing Optical & Precision Materials Co. Ltd., Montreal, development contract, $13,727.
- Bell Telephone Co. of Canada, Ottawa, technical services, $432,794.
- Canadian Charts & Supplies Ltd., Oakville, Ont., recording paper $363,343.
- Canadian General Electric Co. Ltd., Toronto, spares for radar equipment, $22,541.
- Canadian Motorola Electronics Ltd.,

Toronto, transmitting-receiving equipment and ancillaries, $17,766.

- Collins Radio Co. of Canada Ltd., Toronto, equipment, $90,924.
- Erie Resistor of Canada Ltd., Trenton, Ont., technical study, $83,374.
- Ertel of Canada Ltd., Montreal, fire control equipment, $24,430.
- Northern Electric Co. Ltd., Ottawa, spares for telephone systems, $58,170.
- Northern Radio Mfg. Co. Ltd., Ottawa, signal generators, $50,368.
- RCA Victor Co. Ltd., Montreal, development contract, $67,028.

New products—cont.

Recording dc microammeter 130

This new microammeter has a basic range of 0-50 microamperes dc with an approximate input resistance of 200 ohms. Dc voltage ranges of 0-10, 50, and 200 millivolts are also included. A drift-free magnetic amplifier, powered by 120 volts, 60 cps, is combined with permanent magnet moving-coil movement. Accuracy within 2% of full scale is guaranteed. The recording microammeter can be used in any circuit providing up to 50 microamperes dc. It may be operated with normal left hand zero, or set for

centre zero operation for such applications as null detection in bridge circuits. Motor or spring driven chart drives are offered with chart speeds of ¾ inch per hour through 12 inches per minute as standard on all models.

Esterline-Angus Co., Indianapolis.

Miniature rectifier transformers 131

Ferrotran Electronics Co. Inc., have introduced a new line of miniature rectifier transformers for the transistor electronics field. Two new families, the I and H series have been developed. The SM, R and S series have been redesigned with a new transformer magnetic material which enables them to deliver twice their previous current output. The transformers operate with an input voltage of 115 vac. They are available for 60 cps or 400 cps use, and can be supplied either in a channel frame construction, hermetically sealed or encapsulated.

William M. Hummel, Port Credit, Ont.

(Continued on page 66)

SARKES TARZIAN

over 95% of all popular rectifier tube types can be replaced with Tarzian tube replacement silicon rectifiers

ultimate reliability, small size— with excellent efficiency— are some of the many Tarzian plus values

S-5251
1600 PIV · 600 MA DC
Replacement for types 5AU4, 5AW4, 5AZ4, 5T4, 5U4, 5Y4, 5W4, 5Y3, 5Z4
S-5207
1600 PIV · 500 MA DC
Replacement for types 6X4, 6063, 6202
S-5011A
1600 PIV · 750 MA DC
Replacement for types 80, 82, 83, 83V, 5Z3
S-5017
1600 PIV · 750 MA DC
Replacement for types OZ4, 5X4, 5Y4, 6AX5, 6X5
S-5018
1600 PIV · 750 MA DC
Replacement for types 5AU4, 5AW4, 5AZ4, 5T4, 5U4, 5Y4, 5W4, 5Y3, 5Z4, 5931, 6087, 6106
S-5019 or S-5162
2800 PIV · 500 MA DC
Replacement for type 5R4
S-5033
4500 PIV · 250 MA DC
Replacement for types 6AU4, 6AX4, 6BL4, 6U4, 6W4, 12AX4, 17AX4, 25W4
S-5343
7000 PIV · 300 MA DC
Replacement for types 816, 836 or 3828 and 866 at reduced voltage
S-5130
10400 PIV · 300 MA DC
Replacement for types 866, 866A, 3828

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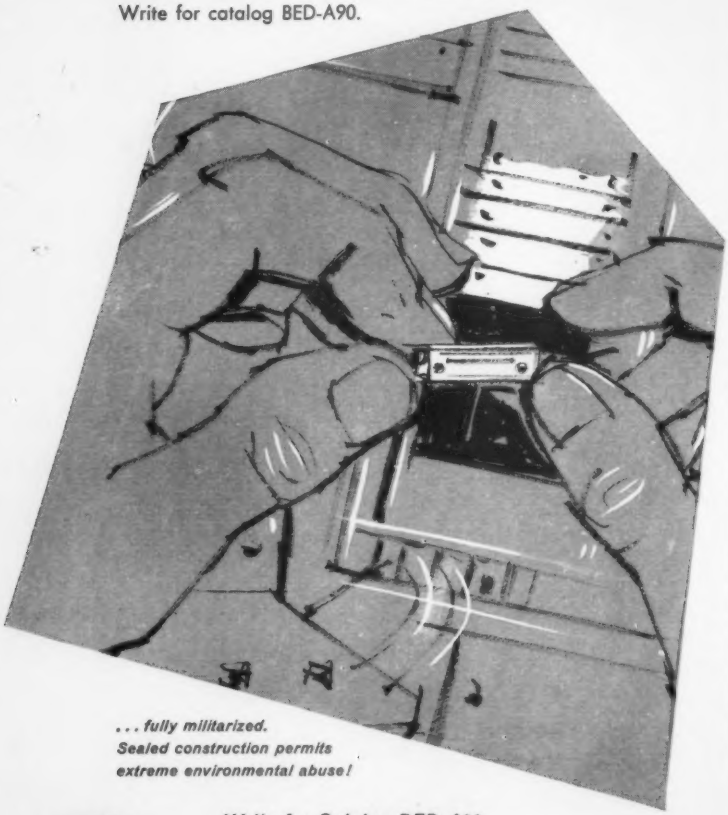

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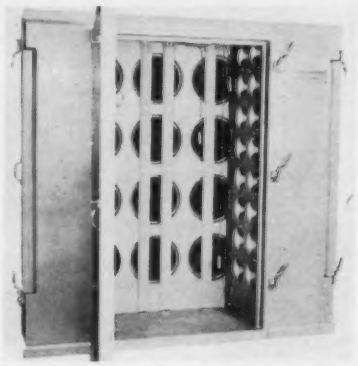
MICROPOTS • MICRODIALS • INSTRUMENT MOTORS • FREQUENCY STANDARDS

For further information mark No. 19 on Readers' Service Card

New products—cont.

Acoustic vibration system 132

Sound waves are used in this system for acoustic environmental vibration testing of aircraft and missile components. Basically, acoustic vibration setting differs from electro-dynamic vibration testing in the method of applying electronic signal force to the specimen. In acoustic testing, the electronic signals are fed to

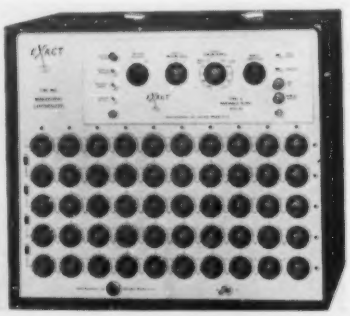


loudspeakers or other transducers rather than to the mechanical shakers which are used in electro-dynamic vibration testing. The new Altec Lansing acoustic vibration testing system consists of an aluminum double-wall reverberation chamber with a 30-cu-ft capacity, and a power supply and control rack. Signals are supplied by eight 260-watt amplifiers. Two band-pass filters control the frequency adjustment of the four low-frequency and four high-frequency amplifiers. The system can produce 147 db of white noise — similar to the noise spectrum of the most powerful jet and missile engines.

Ling-Altec Electronics, Inc., Anaheim, Cal.

Waveform synthesizer 133

Type 200 waveform synthesizer permits the operator to create a stable output waveform of almost any shape imaginable. Unlimited configuration is achieved by separately controlling the characteristics of small segments of the total waveform, using different plug-in units. With the type A Variable Slope plug-in unit, the synthesizer provides an almost limitless number of wave shapes. The amplitude and slope of each of the 50



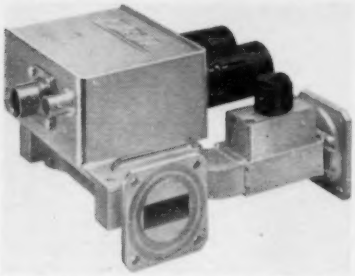
increments may be independently varied without interaction to create the desired waveform; and the over-all amplitude and waveform duration may then also be varied over a wide range.

When used with the type C Variable Width plug-in unit, the synthesizer produces 50 output pulses with independently variable width as well as amplitude. Over-all amplitude and waveform duration may then be varied. Other plug-ins are being developed.

Exact Electronics Inc., Portland, Ore.

Matched microwave preamplifier 134

Matched microwave preamplifier unit model MMX-2 is a mechanically and electrically integrated unit covering the 8.5 to 9.6 kmc range. It has a minimum gain of 25 db, a maximum noise figure of 7.5 db, and a 50-ohm i-f output at

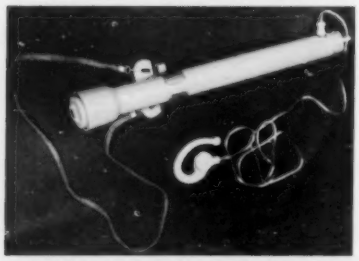


30 or 60 mc. It is available with or without an integral variable attenuator in the LO arm.

LEL, Inc., Copiague, L. I., N.Y.

Lightweight microphone 135

Remote microphone M-60 combines a 1-channel remote amplifier and a microphone into one compact 12-ounce unit. Only 11⅝ in. long, it is designed for mobility in covering sporting events, spot newscasts and other remote broadcasting situations. The microphone is completely sealed and has an omnidirectional polar pattern. It attaches to the threaded amplifier assembly allowing the two units to be separated without disturbing the microphone's factory-sealed chamber.



Amplifier output is + 12 dbm (after 3 db pad) at 2% or less distortion. Frequency response is ± 1.5 db from 60 to 15,000 cps. Relative noise at amplifier input is -119 dbm. There is a built-in 3 db isolation pad between the output transformer and line. It is powered by a 5.4 volt mercury cell with a life at least 100 hrs.

Collins Radio of Canada Ltd., Toronto. END

Proven Performance!

View of mountain top microwave installation

. . . proven performance, where rough conditions are normal all year. Here is a high mountain-top tower where ANDREW equipment was installed to perform, exposed to 100 mph winds, driving sleet, ice and snow.

Selection of the best antenna systems for such problem installations is made easy through a choice of 30 ANDREW stock parabolic reflectors, which utilize the three standard microwave feeds. And tower work has been simplified too, with the new mount, which has separate elevation and azimuth adjustments for precise alignment.

All standard ANDREW antennas meet or surpass EIA recommendations and DOT specifications, governing radiation patterns and side lobes.

Uniform all weather performance is assured by the use of radomes and built-in automatic de-icing equipment.

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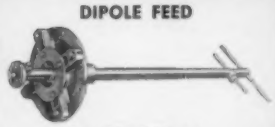
DIPOLE FEED



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WAVEGUIDE HORN FEED

for 3700-13,200 mc

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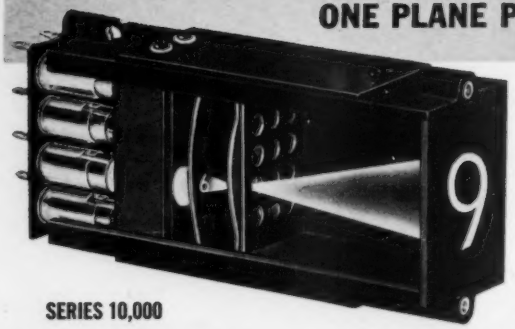

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- Reliable, dependable, no moving parts.
- All digits displayed on front surface viewing screen...quickly seen from any angle of viewing.
- All digits uniform in size and intensity...easier and faster to read.
- High-contrast viewing screen insures utmost visual sharpness.
- Digit style of your choice to complement manufacturer's original equipment.
- Colored digits of your choice for special environmental lighting.
- Individual units may be assembled in groups for convenient panel mounting.
- Dimensions: 1-9/16" wide, 2⅝" high, 5⅝" long.

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Representatives in principal cities

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Series 80,000

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Whatever your soldering problem, American Beauty has the right iron for your particular job. The finest engineering, best materials and on-the-job experience since 1894 is yours with EVERY American Beauty. There is a right model, correct tip size (¼" to 1⅛") and proper watt-input (30 to 550 watts) to do any soldering job. Ask about which iron will do your job best. American Beauty electric soldering irons are the highest quality made.

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TEMPERATURE REGULATING STANDS
Automatic devices for controlling tip-temperature while iron is at rest—prevent overheating of iron, eliminate frequent retinning of tip, while maintaining any desired temperature. Available with heavy-gauge perforated steel guard—protects user's hand.

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AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN
American Beauty ELECTRIC IRONS SINCE 1894

For further information mark No. 11 on Readers' Service Card

Reports—continued

Sylvania quits Canadian tv market

Sylvania Electric (Canada) Ltd. has suspended the manufacture and distribution of television sets in Canada. They will concentrate their efforts on the expansion of lighting and industrial electronic products.

In making the announcement president R. E. Niedringhaus said, "In Canada today, the public is purchasing about 400,000 tv sets a year. The country currently has production capacity for three times that many receivers and the outlook over the next several years does not indicate a sharp upturn in consumer demand for sets."

Sylvania will continue to provide service for existing consumer products.

New companies and facilities

United Electric Controls (Canada) Ltd., O'Connell Ave., Dorval, Que., is the new Canadian manufacturing company formed by United Electric Controls Co., Watertown, Mass. They will produce temperature, pressure and vacuum controls.

Evershed-Powertronic Ltd. has been formed by Evershed & Vignoles (Canada) Ltd. and Powertronic-Equipment Ltd. to provide Canadian-engineered and -manufactured instrumentation and telemetering systems. Vice-president and general manager of the new company is H. G. Dawson, P.Eng., former general manager of Evershed & Vignoles (Canada) Ltd. Offices are at 50 Bermondsey Road, Toronto 16.

Delta Electronics Ltd. has moved into a new 15,000-sq.-ft. plant at Park Royal, the manufacturing-residential area west of Lorne Park on the western outskirts of Toronto.

Standard Electric Time Co. of Canada expects to move into its new plant next February. It is being built in Pointe Claire Industrial Park, Montreal.

H. A. Hoyles, Mem.I.R.E., and P. A. Niblock, Mem.I.R.E., have formed a new company of consulting telecommunication engineers and attorneys under the name of **Hoyles, Niblock and Associates.** Their services cover radio and television broadcast stations, and radio and wire communication systems. Offices are at 1846 Beaulynn Place, North Vancouver, B.C. Telephone: YUkon 7-7664.

Metal masts for Europe

Beatty Bros. Ltd., Fergus, Ont., have been awarded a contract, through Canadian Westinghouse Co. Ltd., to

build portable microwave masts for use in the Western European Defence. The 150-foot masts will carry large area reflectors for two high-frequency microwave systems.

As far as CEE editors are aware, this marks the first time such products have been exported from Canada.

New principals and representatives

Precision Electronic Components (1956) Ltd. has been appointed sole Canadian representative by Athom Electronics, manufacturers of trimmer potentiometers.

Canadian Research Institute has announced three new business appointments. They will handle sales of seamless metal tubing (ferrous, nonferrous, nickel and nickel alloy), aluminum tubing, and semirigid coaxial cable manufactured by Precision Tube Co., Inc., North Wales, Penna. Repairs and recalibration of thickness meters manufactured by Kocour Co., Chicago, Ill., will be undertaken by C.R.I. in Toronto. The company has also been appointed Canadian representative for Microsprings, s.r.l., Milan, Italy, manufacturers of spiral hair springs for instruments.

Tellurometer Canada Ltd. has been appointed Canadian and U. S. agents for Mervyn Instruments of England, manufacturers of scientific instruments and electronic equipment. The company has also been appointed Canadian and U. S. agents for special-purpose Shaw hygrometers and moisture meters.

Fischer & Porter (Canada) Ltd. has been appointed a distributor of the full line of laboratory glassware manufactured by Kimble Glass Co., Toledo, Ohio, a subsidiary of Owens-Illinois.

Precious metal price reduction

Consolidated Mining & Smelting Co. of Canada Ltd., has reduced the price of special research grade indium. New price is $16 per troy ounce in quantities of 5-199 ounces; $14.50 per troy ounce in quantities of 200 ounces or more.

Post Office Department speeds mechanization

Hon. W. Hamilton, postmaster-general has announced plans for a downtown postal station in Edmonton. It will use one of the English letter-sorting machines to sort letters for local and outside distribution, and cancel stamps automatically. One of these machines is scheduled for installation in Winnipeg in 1961.

Production model of Canada's letter-sorting machine, now under final development at Canadair, will be installed in Montreal general postoffice next spring. It is only one of several new machines and pieces of equipment under test during a five-year postal progress plan. J. Nelson Craig, former Toronto postmaster, has been appointed director of the Engineering and Development branch of the Post Office Department.

TV servicemen set standard rates

Television repairmen in New Westminster, B.C., have established a standard of rates and services for their own and customer protection. Rates and services will be published, along with names of repairmen agreeing to them. About 95% of the servicemen in the area have agreed to the proposals.

House calls will cost $5.95 plus parts. This covers labor up to one half hour. If replaced parts fail within 90 days, they will be replaced again without charge. If further repairs are needed within 90 days of the call, only half the house call fee will be charged for return calls.

Shop charges range from $14.95 up to a maximum of $24.95 plus parts.

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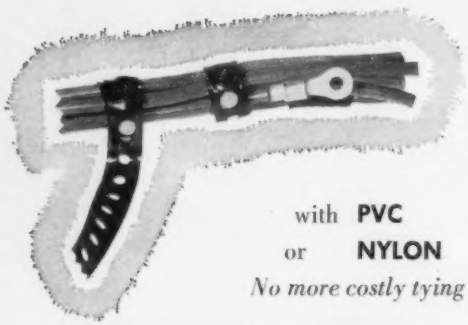

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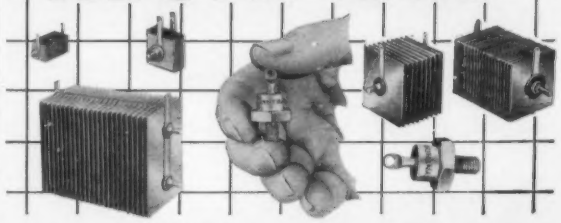

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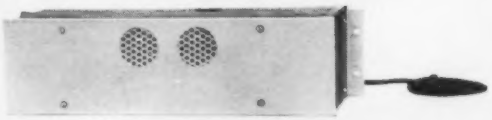

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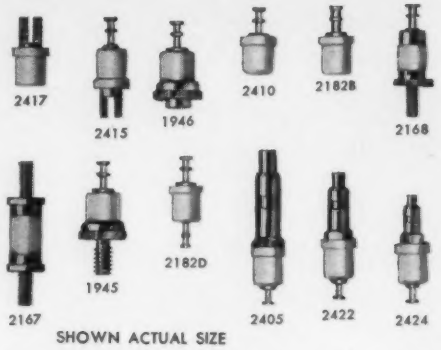

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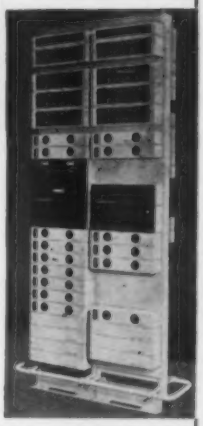

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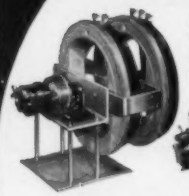

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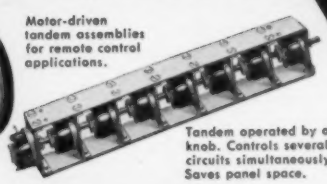

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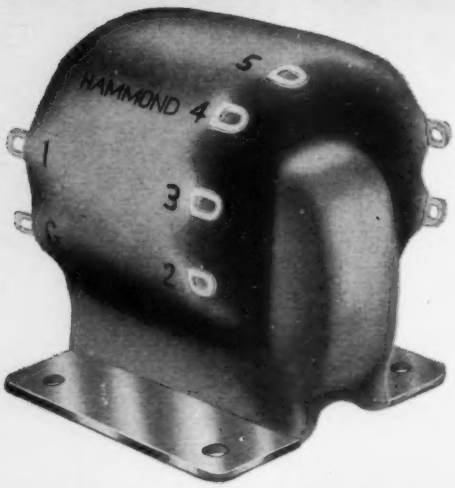

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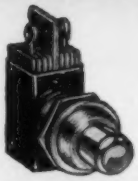

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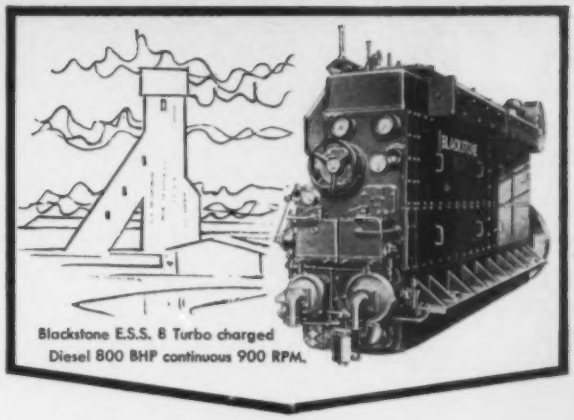

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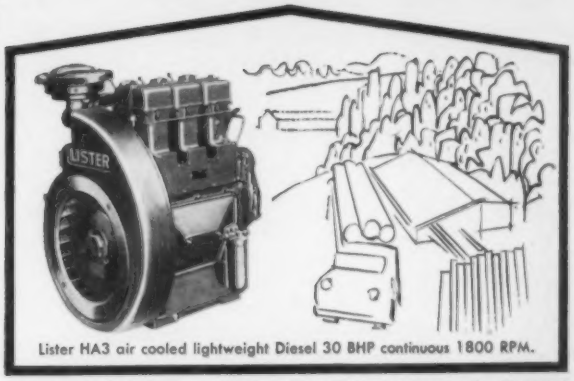

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Broadcast engineers strive to improve their status

One of the main points of discussion during the 1959 meeting of the Central Canada Broadcasters Association, Engineering Section, was the status of the station engineer. With his technical knowledge and familiarity with programming, he can be a valuable member of the team planning station expansion and operation.

In general, however, these extra capabilities of the broadcast engineer are not recognized or utilized by management. Plans were discussed whereby the status of engineers could be improved by acquainting management with the benefits that could be realized through more efficient use of engineering talents.

Two new CCBA engineering committee members (seated l-r) D. Duffield, CFPL-TV London, and G. Ballantyne, CKGN-TV North Bay, get advice from retiring members F. Lehman, CFRB Toronto, W. Onn, CHLO, St. Thomas, J. Smith, CKCO-TV Kitchchener.

During the two-day meeting in Toronto, CCBA engineers elected their committee for 1960, listened to technical papers, and saw recent developments in equipment.

Most of the papers this year were presented by members of CCBA, and the quality was considered to be somewhat higher than average. Equipmentwise, there was quite a trend toward tape cartridges for spot commercials and announcements. Four different types were shown by exhibitors. Special effects TV generators came in for quite a bit of attention too. Several models were shown.

Next year? Dates and other arrangements will be discussed at the first meeting of the new executive, but the annual meeting probably will be held in Toronto near the end of October.

Toronto chapter PGCS elects chairman

At its meeting on November 2, the Toronto Chapter of the IRE Professional Group on Communications Systems elected F. A. Ford to be its first chairman. Purpose of the chapter is to foster activities and exchange of information in the field of communications systems.

McMaster opens new engineering building

On October 23 Dr. K. F. Tupper, O.B.E., opened the new $3½-million engineering building at McMaster University, Hamilton. The 165-room building has been designed for a future enrolment of 550 students. Courses leading to a Bachelor of Engineering degree are available in chemical, civil, electrical, mechanical and metallurgical engineering and in engineering physics. The first class will be graduated in 1961.

Dr. Tupper is immediate past president of the Engineering Institute of Canada and the former dean of engineering at the University of Toronto.

University of Toronto starts fund drive

The University of Toronto has undertaken an extensive development program that will cost $52,359,000 during the next five years. This will provide minimum facilities for the over-all enrolment which is expected to grow from the present 13,000 to 23,000 by 1968.

Contributions may be sent to: The National Fund for the University of Toronto, 203 Simcoe Hall, Toronto 5.

U.S.S.R. and Canada to exchange scientists

A delegation of the National Research Council, headed by President E. W. R. Steacie, stayed in the Soviet Union from October 11 to October 29 at the invitation of the USSR Academy of Sciences. The delegation also included Dr. B. G. Ballard, and professors Farquharson, Thode and Cowan.

On Oct. 28, A. Nesmeyanov, president of the USSR Academie of Sciences, and Dr. Steacie signed an agreement on regular exchange of scientists beginning with the 1960-61 academic year.

Three scientists a year will be exchanged for periods of up to three weeks for delivering lectures, holding seminars and studying the activities of scientific establishments. An annual exchange of scientists (up to seven people) will also be maintained for carrying out research at scientific establishments of the other country for a period of from three to nine months.

COMING EVENTS

January 1960

25-29 Stress Measurement Symposium, Arizona State University, Tempe, Arizona.

February

3-5 IRE-PGMIL winter meeting, Los Angeles, Calif.

19-23 Third International Exhibition of Electronics Components. Paris, France.

March

21-24 Radio Engineering Show and IRE National Convention, New York.

April

4-8 6th Nuclear Congress, N.Y. Coliseum, N.Y.

5-9 9th Electrical Engineers Exhibition, Earls Court, London.

May

2-4 National Aeronautical Electronics Conference, Dayton, Ohio.

June

6-8 3rd Canadian National Business Show, Automotive Building, Toronto.

27-29 National Convention on Military Electronics, Washington, D.C.

What's ahead for electronics?

During the past four years the Canadian electronics industry has been on the decline. However, early indications are that the curve may have started to climb again during late 1959.

To find out just where we now stand, CEE has been compiling statistics and consulting with many people both in and near the industry. The results will appear as the main editorial feature of CEE's Industry Review and Forecast issue in January.

The issue will also include technical articles and full regular departmental news coverage.

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DECEMBER 1959

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116	117	118	119	120	121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	140	141	142	143	144	145
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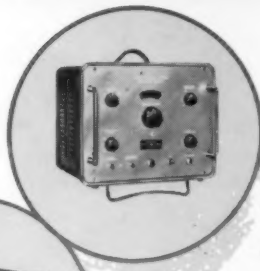

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- **Model L771B: 950 to 2000 MC/SEC.**
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- **Model X772A: 7000 to 11,000 MC/SEC.**
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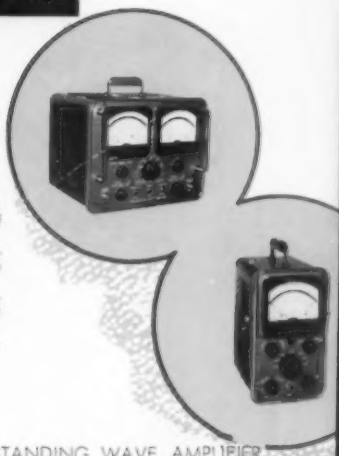
RATIO METER AND STANDING WAVE AMPLIFIER IN ONE COMPACT PACKAGE



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- **Crystal and bolometer operation.**

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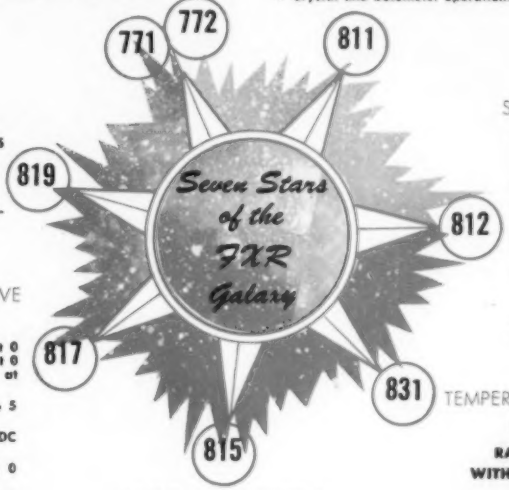
- **Beam: 300-1000 V at 85 MA.**
- **Grid: −300 to +150 V at 0 to 5 MA. Built-in limiting resistor.**
- **Reflector: 0-900 V at 10-20 μA.**
- **Regulation: 1%.**
- **Internal Modulation: pulse, sawtooth, square wave.**



STANDING WAVE AMPLIFIER

- **A 5-inch removable meter with 1% linearity provides high resolution and accuracy.**
- **A filter, tunable between 950 and 1050 CPS, aligns instrument with output frequency of signal source.**
- **Range: 70 DB in six decade steps. Normal and expanded scales for VSWR and DB.**
- **Gain automatically maintained when switching from normal to expanded scales.**
- **Detectors: crystal or bolometer.**
- **Full scale sensitivity, 0.1 μV: signal-to-noise ratio, 3:1.**

UNIVERSAL MICROWAVE POWER SUPPLY

- **Helix (beam): 0 to 1800 V at 0 to 100 MA; 1700 to 2500 V at 0 to 100 MA; 2500 to 3500 V at 250 W MAX.**
- ***Grid 1: 0-300 V DC at 0 to 5 MA.**
- ***Grid 2 (reflector): 0-1200 V DC at 0 to 1 MA.**
- ***Grid 3 (focusing electrode): 0 to 750 V DC at 0-1 MA.**
- ***Grid 4 (focusing electrode): 0 to 500 V DC at 0-1 MA.**
- **Collector: 0-300 V DC at 0-100 MA.**
- **Anode: 0-600 V DC at 0- 60 MA.**
- **Filament: 0-15 V DC, 0-3 AMP at 20 W MAX.**

**May be internally modulated: pulse, sawtooth, square wave.*

TEMPERATURE COMPENSATED POWER METER

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- **A hundred times more stable than comparable instruments—readings virtually drift-free.**
- **Six ranges—10 μW to 3 MW full scale.**
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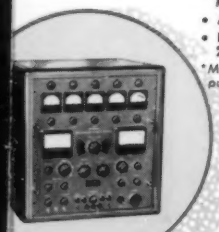
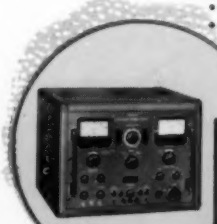


UNIVERSAL KLYSTRON POWER SUPPLY

- **Beam: 200 to 2000 V at 0 to 125 MA, 1800 to 3600 V, 250 W to 3600 V.**
- **Control Grid: Pos. 0 to 150 V, Neg. 0 to 300 V.**
- **Reflector: 0 to 1000 V.**
- **Regulation: 0.03%.**
- **Ripple: 3 MV, RMS, MAX.**
- **Internal Modulation: pulse, sawtooth, square wave.**



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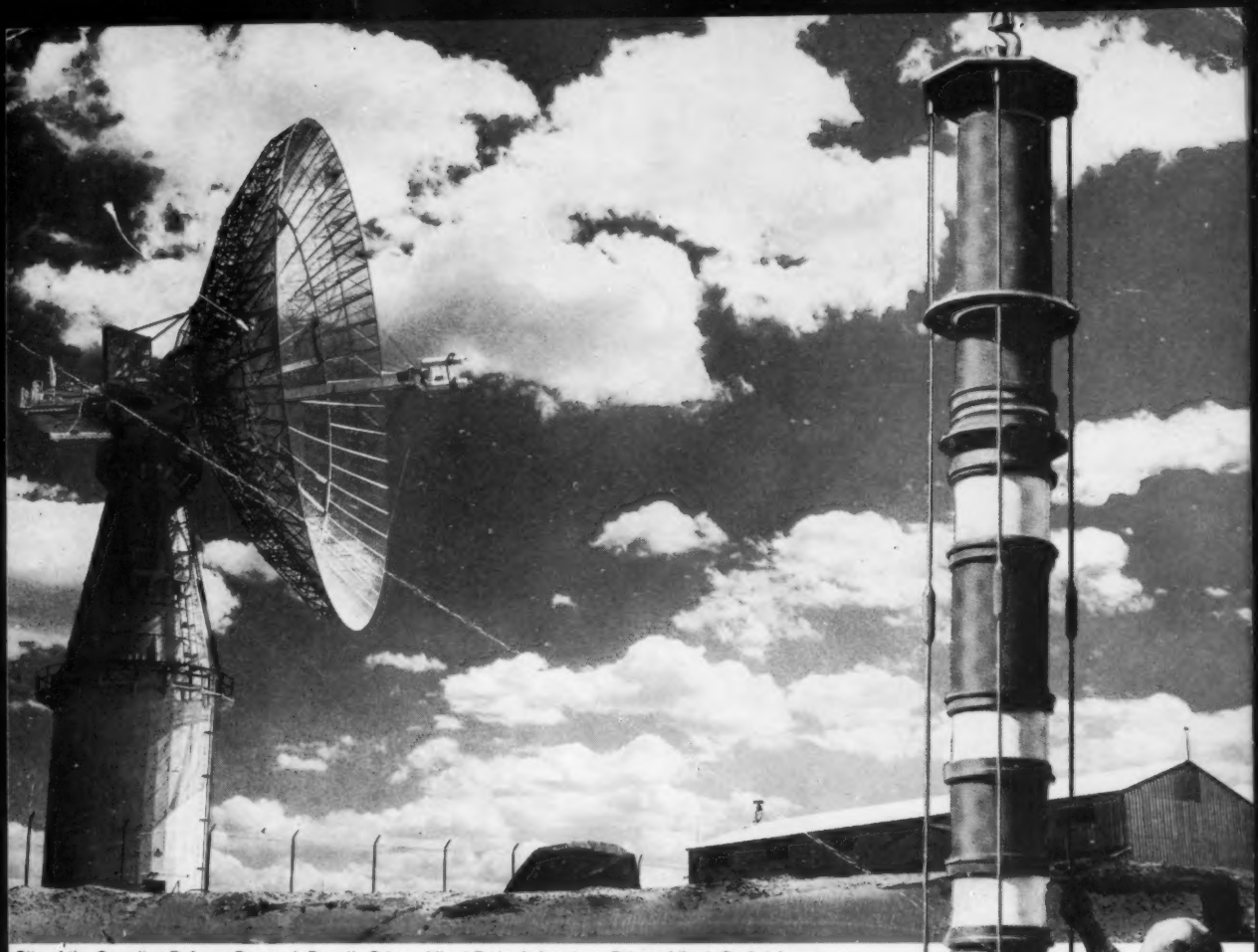

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